PARC NATIONAL DE LA GARAMBA
GARAMBA NATIONAL PARK PROJECT

RHINO MONITORING

TRAINING MANUAL

Garamba National Park Project Report
1996

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PARC NATIONAL DE LA GARAMBA

RHINO MONITORING
TRAINING MANUAL

PARC NATIONAL DE LA GARAMBA

RHINO MONITORING TRAINING MANUAL

INTRODUCTION

The purpose of this manual is to outline the format for rhino monitoring data collection at Garamba National Park, in order to guide training of guards or others in the methods, at different levels of complexity and in different subject modules. It serves also to consolidate examples of the data sheets, maps, definitions and guidelines used.

RHINO MONITORING OBJECTIVES

1. To monitor the population dynamics, movements, home ranges, basic behaviour and ecology of the rhinos, in order to contribute to their conservation and protection.

2. To maintain a field presence in the rhino sector and to detect signs of poaching threat or other danger.

TRAINING OBJECTIVES

1. To provide structured guidelines for frequent training and re-training of guards in rhino observation and accurate recording of observations at three levels of advancement.

2. To improve the contribution of guards to the overall monitoring of the rhinos.

3. To motivate interest in, knowledge of and greater identification with the rhinos and to promote more comprehensive coverage of the rhino sector.

TARGET GROUPS

1. All guards and others who may be in a position to report a sighting of a rhino/s, need to know the basics of what is required. (Level 1)

2. Guards selected specifically to contribute to rhino monitoring need to receive training to levels 2 and 3.

3. For researchers or anyone working on or related to the rhinos, this provides a consolidation of some the field methods and data sheets.

LEVELS

1. Ability to complete the basic data sheet including simple map-reading and four figure coordinates, broad age and sex classification, simple habitat format, activity, associated species, to make observations to guide identification, measure footprints, to relay information on the radio when necessary and care for and use of binoculars.

2. Ability to make reliable identifications of marked individuals, full habitat classification, do radio tracking, and record the basic feeding and activity data sheets and care for equipment, to take basic compass bearings and to relay information on the radio in security code.

3. Ability to do the above, make reliable identifications of all individuals and make detailed behavioural observations, as in the data sheet "L'activite des rhinos", faecal collections or other samples as required and full use of a compass.

AWARDS

- Rhino observations are rewarded with bonuses at three levels of information, verified by the Rhino Protection Officer (RPO) or the Monitoring and Research Coordinator (MRC)

- Completion of a practical and theoretical course is awarded with a Certificate.

- A gold rhino badge is awarded to guards successfully proving level 3 ability.

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FORMATION DE MONITORING RHINOS

Date Theorie.................

Date Pratique.................

NOMS DES GARDES:															
NIVEAU 1															
Effort de recherche rhinos et communication															
Utilisation jumelles															
Lire carte et coordonees - Theorie															
Lire carte et coordonees - Pratique															
Classification age et sexe - Theorie															
Classification age et sexe - Pratique															
Habitat, condition endroit - Theorie															
Habitat, condition endroit - Pratique															
Activite - Theorie															
Activite - Pratique															
Espece associe - Theorie															
Espece associe - Pratique															
Observations pour identification - Theorie															
Observations pour identification - Pratique															
Mesures de traces - Theorie															
Mesures de traces - Theorie															
Identification de l'observateur															
NIVEAU 2															
Coordonees detaillees															
Classification de l'habitat detaillee - T															
Classification de l'habitat detaillee - P															
Identification d'individus - T															
Identification d'individus - P															
Radio telemetrie - T															
Radio telemetrie - P															
Utilisation de bourselle - T															
Utilisation de bourselle - P															
Utilisation de phonie et code de securite															
Fiche de donnees activite simple															
Fiche d'observations nourriture															
NIVEAU 3															
Preuve de faire tous au dessus a bon niveau															
Fiche Activite des Rhinos															
Recolte des echantillons															
Utilisation de bourselle en RT															

NIVEAU 1															
NIVEAU 2															
NIVEAU 3															

PRIMES POUR DES OBSERVATIONS DES RHINOS

Niveau 1

Chaque observation complete avec date, heure (approximate), localisation, nombre, et classe d'age des rhinos et habitat (approximate).

Niveau 2

Observation avec identification verifiée et au moins une demi heure d'observation.

Niveau 3

Bonne observation avec toutes les données verifiées et quelques heures d'observation bien ecrites.

Toutes les observations doivent etre ecrites sur fiches, notifiées au Giningayo et fournis à Dr Kes ou Dr Mbayma pour discussion et verification. Les primes seront basées sur les verifications de l'un ou de l'autre.

Nagero
le 2 Decembre 1995

REPUBLIQUE DU ZAIRE

MINISTERE DE L'ENVIRONNEMENT, CONSERVATION DE LA NATURE ET TOURISME

INSTITUT ZAIROIS POUR LA CONSERVATION DE LA NATURE

GARDE DE PARC

PARC NATIONAL DE LA GARAMBA

OBSERVATEUR EN MONITORING DES RHINOS

Nous, soussignes, Dr Kes Smith
et Dr Mbayma Atalia
decernons a:

Monsieur..

ce brevet d'Observateur en Monitoring
des Rhinos

pour avoir suivi les cours pratique
et theorique
et reussi avec success les tests
y relatifs
a niveau........

Dr Mbayma Atalia
Conserateur Principal
(Chercheur)

Dr Kes Hillman Smith
Conseillere Technique
(Ecologie)

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Fait a Nagero, le....../....../1996.

METHODS

Rhino monitoring is done from both air and ground. The graph shows the relative efficiency of different types of monitoring as classified and coded on the Table CATEGORIES OF TYPES OF SEARCH METHODS THAT YIELD RHINO SIGHTINGS

AERIAL

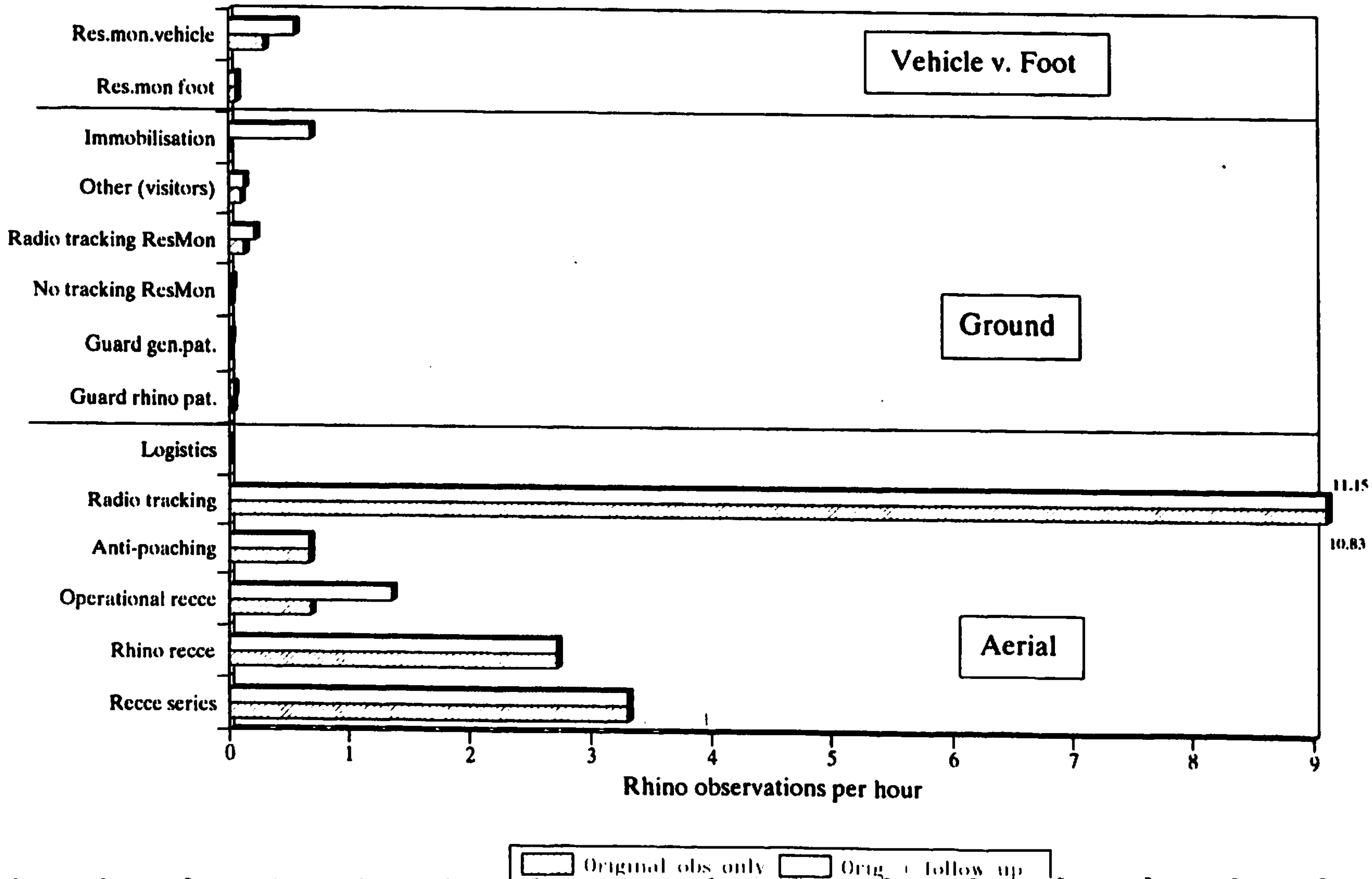
RS The *rhino recce series* involves covering the whole potential rhino sector from the air as total count blocks. The blocks are defined on the accompanying map. Their boundaries are geographic features, such as rivers and roads. Each block is flown by a series of parallel straight line transects, at 300-500 ft agl, depending on grass length. Visibility is better from slightly higher when the grass is long. though with minor variations if it is felt that an area, for example of long grass has not been adequately covered. The transects are spaced roughly 1 km apart, but this also varies with season. When the grass is short in late dry and early wet seasons, coverage does not need to be as intensive as during the long grass period. Flight time is generally 1.5-2.5 hours per flight, with 1-2 hours over the block/s in question, depending on placement time. Flights are carried out early morning and late afternoon, when the rhinos are most active and flying is least turbulent. Due to the uncertainty of the weather in the afternoons it is sometimes more productive to concentrate on morning flights in the wet season. On this basis the series takes a week and 12-14 hour flying time.

The recce series is most efficient in terms of numbers of different individuals per unit time (3.3/hr) and it gives a broad objective coverage of the sector, with a theoretically equal chance of seeing any individual, and the chance of detecting any signs of poaching or incursions. Due to the time it takes and fuel used, however, it cannot be repeated more than once a month, which would give time for poachers to enter undetected and for carcases to disappear.

RR *General rhino recces* are isolated flights made in the same manner, but without being part of a series. The purpose may be to search for a particular rhino/s that have not been seen for some time, to search for suitable rhinos for immobilisation for radio telemetry or biopsy darting, to cover an area where danger might be suspected, to check up on a new calf, to find rhinos for important visitors or donors (though generally the latter is tied in with part of the on-going work), to do an overview recce if the aircraft had been absent for some time and a recce series was not feasible. Although slightly less efficient in terms of different individuals seen, especially when searching for "missing" individuals, they may be necessary for one of the reasons given above. Their additional function is in increasing frequency of reconnaissance to increase chances of detecting carcases or other signs of poaching. Radio telemetry, however, when used fills this latter purpose coupled with more than trebling the efficiency of rhino sighting per hour.

OR *Operational recces* are the follow up flights specifically backing up a ground operation such as immobilisation for radio telemetry, or biopsy darting. During

RHINO SIGHTINGS PER TYPE OF MONITORING
January-May 1996



CATEGORIES OF TYPES OF SEARCH METHODS THAT YEILD RHINO SIGHTINGS

AERIAL

RS Rhino recce series
RR General rhino recces
OR Operational rhino recces (eg immobilisation, biopsy darting etc)
RT Radio telemetry of rhinos
AP Anti-poaching recces
OT Other (eg burn counts, elephant radio tracking)
LO Logistics

GROUND

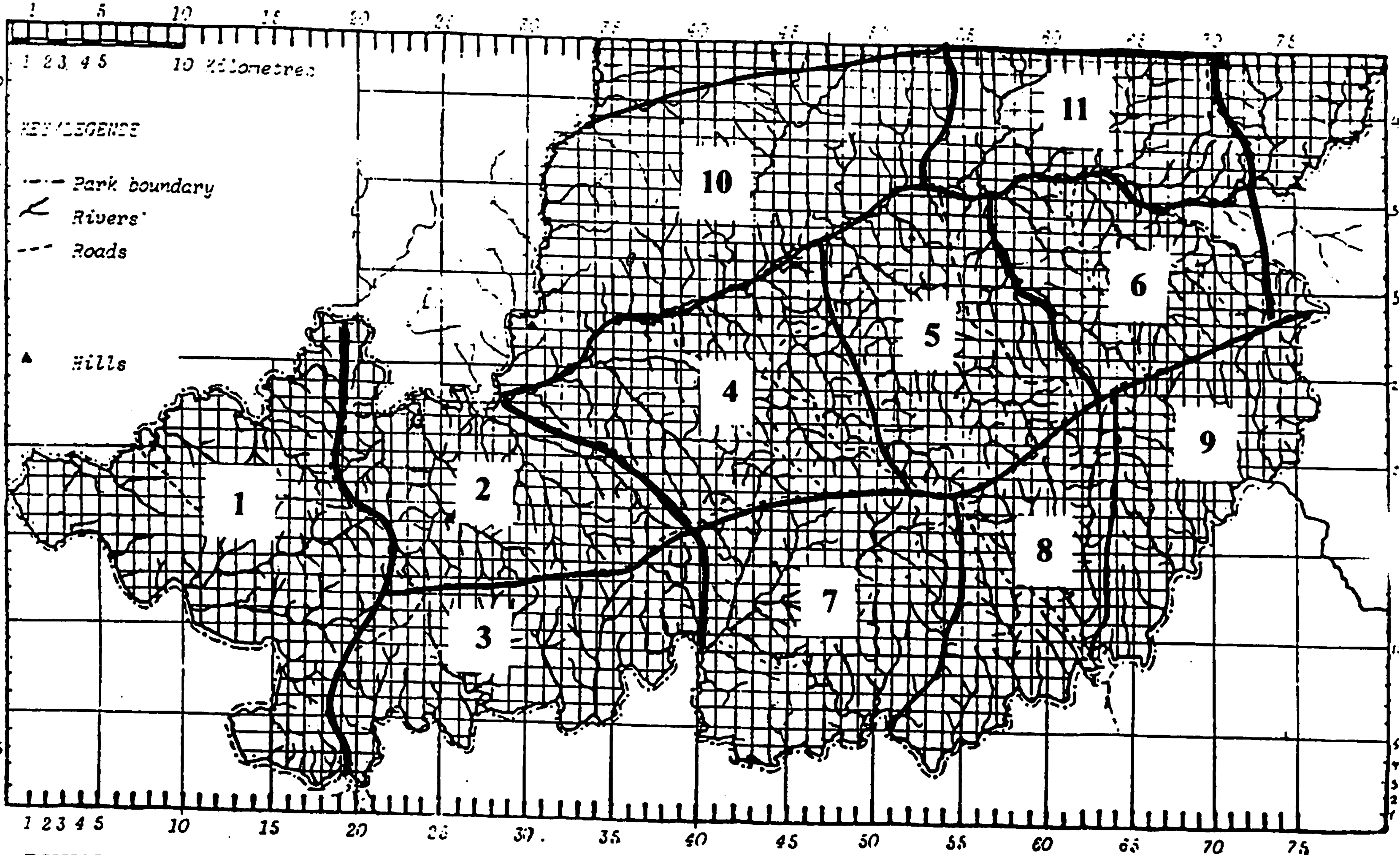
GR Guard rhino observation patrols
GG Guard general patrols
RM Research and monitoring rhino ground work
RTG Radio telemetry from the ground
AG Air to ground link to guide in ground observation
OT Other, (eg burning, vegetation, elephant or other studies)
OR Op. recce

FLIGHT CLASSIFICATIONS

PERIOD: 1= 0600-0900 hrs; 2=0900-1200 hrs; 3=1200-1500 hrs; 4=1500-1800 hrs

SECTOR: Block of park as defined on map. All in southern sector below line level with Bagunda.

1 Far west, to Aka/Dungu confluence
2 Willibadi 1, Podo Nangume
3 South of 2
4 Nangume to Kiliwa
5 Kiliwa to Aligaru
6 Aligaru to Dodo
7 Willibadi 11
8 Triangle
9 East of triangle to Namalombia
10 North of Garamba River to west
11 North of Garamba river to east



RHINO MONITORING BLOCKS
PARC NATIONAL DE LA GARAMBA (Southern sector / Secteur sud)

operation such as immobilisation for radio telemetry, or biopsy darting. During immobilisation the aircraft has to be in the air to direct the ground team in and to follow the rhino before it goes down and direct the ground team to it.

RT *Radio tracking* recces are flights primarily for the purpose of radio tracking rhinos. They are generally made at a higher altitude, because signal range detection is greater the higher the altitude above ground. Descending to normal rhino searching height, 300ft, or lower is often necessary to be able to identify all associated individuals, but this can be done gradually and using this method, especially when current group compositions are known it is often unnecessary to do a low pass for identification.

Radio tracking is by far the most efficient method of frequent recovery of specific individuals, yielding 10-11 rhinos per hour. Through associations and chance sightings, more individuals are seen than just those with transmitters. For example during 1996, 18 different individuals were regularly seen for 5 with transmitters. In addition it has the advantage of leading to frequent coverage of the area, increasing the chances of detecting carcases or signs of poaching incisions. However it does not give potentially equal search effort to all individuals.

AP *Anti-poaching recces* are primarily for looking for signs of poachers, but they may yield chance sightings of rhinos, or be tacked on to a rhino recce. All rhino recces have an anti-poaching reconnaissance function within the rhino area, through fulfilling objective 2, but AP flights are those where the primary purpose is anti-poaching.

OT Flights for *other* reasons, such as counts of the burn areas and elephant radio tracking often lead to rhino sightings and every effort is made to make most effective use of flying time by combining purposes.

LO Chance sightings of rhinos may occur on *Logistical flights* over the park, especially since every effort is made to combine functions for efficient use of flight times. Flights are classed as LO when the primary purpose was of a logistical nature, such as returning from a field camp or depositing supplies.

GROUND

GR *Guard rhino observation patrols* are those patrols of guards in the rhino sector orientated specifically towards monitoring rhinos, and comprising at least some trained individuals.

GG *Guard general patrols* are those patrols of guards whose main function is anti-poaching reconnaissance and action, but who may have chance sightings of rhinos.

RM *Research and monitoring* rhino ground work are those patrols consisting of at least one researcher, who carry out motivated and purpose orientated rhino searching. This can include searching for rhinos for specific studies, seeking specific rhinos for biopsy darting, identification up-dates, calf verification, training and systematic coverage of areas. For the purpose of the analysis, this type of ground work was also divided into that aided by a vehicle and that carried out purely on foot. Even when a rhino has been seen or a radio signal detected from a vehicle, final follow up is always on foot. Use of a vehicle, within a situation where radio telemetry contributed to both approaches was three times more efficient, (0.14 rhino/hour compared with 0.05 rhino/hour), but only 1.2 times more expensive per rhino. Guard patrols may also be backed up by a vehicle to increase mobility and efficiency, but balanced by foot work to reduce advertising their presence to rhinos or poachers.

RTG *Radio telemetry* , when animals are bearing transmitters is used to improve the effectiveness of monitoring and protecting vulnerable individuals and of greatly facilitating studies. As with the aerial tracking it is of the order of ten times more efficient and has a major effect on increasing motivation. Telemetry is used by guard patrol and research and monitoring patrols. RTG classed sightings are those where a rhino has been found specifically through radio tracking. It may include associates of the rhino with the transmitter.

AG *Air to ground link* is the approach to a rhino or group of rhinos on the ground, specifically guided in by an aircraft. This category usually applies to approaches for immobilisation for radio telemetry or biopsy darting.

OT *Other* are ground based rhino observations made in the course of another primary task, such as burning, vegetation, elephant or other studies.

- Aerial monitoring is more efficient than ground monitoring in terms of numbers of rhinos seen per unit effort, (3.3 rhinos / hour for RR, compared with 0.03 rhinos / hour for ground patrol, but

- Ground based monitoring and patrols are necessary to fulfil the protective function, to seek for signs of rhinos or poaching incursions, and to get close, up-to-date information on identification features and to collect data towards the studies. Such data collection also fills a dual protective role in increasing the field presence with the rhinos.

FLIGHT TIME CLASSIFICATIONS

- These are the periods of the day into which the flight times are grouped for entry on the flight data sheet and for analyses. They also correspond to the periods that have been used for analyses of rhino activity patterns.

SECTOR

- The blocks of the park in the southern sector used for rhino searching during the recce series are defined in the table and on the 1:278,000 map with 1x1 grid squares that is used for rhino observations.

SUBJECT MODULES

1. SEARCH EFFORT AND COMMUNICATION

- It is important to remember that the two purposes of the rhino monitoring are:
  1. To find, observe and report on rhinos as frequently as possible
  2. To detect any signs of poaching incursions or other danger to the rhinos and to counteract them.

  To this end, active searching and follow up must take place, not just following an itinerary.

RHINO SEARCH EFFORT

- Stop and search carefully with binoculars from high points, and investigate any rhinos or possible rhinos, without disturbing them, in order to identify them.

- Approach from the downwind side and reduce noise to a minimum. For basic monitoring there should be no need to disturb the rhinos. Do not go closer than is necessary for the observations required, and for normal observation do not go closer than 50 metres. If the wind is changing retreat before disturbing them if possible. Getting scent of people on the ground is generally the most disturbing thing and may send them tens of kilometres away.

- Bear in mind their activity patterns when searching, ie early morning and evening they are more likely to be moving and feeding; middle of day, more likely to be resting, lying in termitaria in long grass or under trees.

- If fresh tracks are found, follow until the rhino/s are found.

- If old tracks are found measure and record number of rhinos, habitat, direction and estimated age since made.

MEASUREMENT OF TRACKS

- Tracks are measured as shown on the diagram **RHINO SPOOR MEASUREMENTS**

- T plus the number of individuals represented by the tracks is marked in the **Tot.** column. The measurements are written in the column **Traces** .

- It is particularly important to record and measure tracks of known individuals or tracks in unusual areas.

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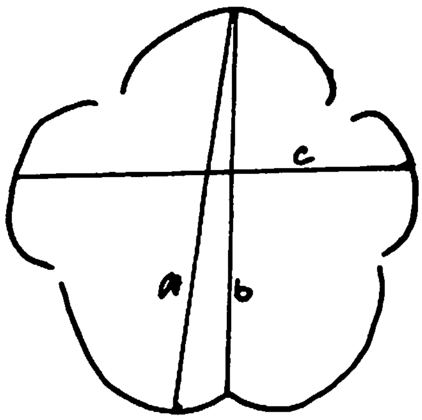
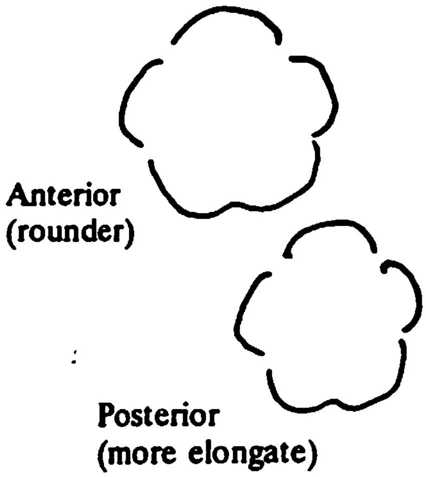
RHINO SPOOR MEASUREMENTS

Rhino spoor measurements are taken as follows:





and recorded: a-b x c (A) or (P) for anterior or posterior.

They are noted on the basic *Rhino Observation sheets* under "*Tracks*".
If they are tracks measured in the absence of the animal they are recorded as *Tn* (where n = the no. of animals represented). in the *No.Tot.* column.

Objectives

a) In order to report the presence of rhinos in an area even if rhinos are not observed. This has led to some indications of rhino presence in areas outside their known range.

b) For measurements of specific known individuals and/or age/sex classes, in order to be able to draw up a table of age specific sizes.

c) We have tried to use tracks for individual identification, but in only a few cases are there characteristics specific enough for identification.

REPORTING

- Every observation of a rhino or group of rhinos is reported on the basic report format and either directly or through the guard inspector given to the MRC or RPO for discussion and verification and for entry to the central database.

- Each observation is also marked on the monthly table of rhino observations, a large copy of which is in the Research Office, in order to keep track of which rhinos have been seen and which have not.

- Depending on the type of patrol a report in should be made every evening or early morning, or if instructions were to search for a particular rhino and report, this should be reported immediately.

- Reporting of rhino positions should be in security code, whereby the coordinates are given relative to an agreed point which is different for each patrol and only known to the patrol and the RPO, PL, MRC, CC and guard inspector.

- If the patrol hears an aircraft flying nearby they should always switch on the radio and try calling to make an immediate situation report or to receive information.

- Rhino monitoring patrols should also mark their itinerary and the positions of any rhino observations or poaching indices on the map ***Fiche de Patrouille*** and should complete a standard patrol summary sheet, which contributes to the **Law Enforcement Monitoring**

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NORTHERN WHITE RHINOCEROS (*Ceratotherium simum cottoni*) MONTHLY SIGHTINGS 1996

ADULT	MALES	JAN	FEV	MAR	AVR	MAI	JUI	JUL	AUG	SEP	OCT	NOV	DEC
M2	'Eleti'												
M3	'Kondo akatani'												
M4	'Bac'												
M5	'Bawesi'												
M9	'Notch'												
1a/4a	'Moke'(Ch2?)												
4a/1a	'Bolete moke'(H.E												
5aM	'Giningamba'												
ADULT	FEMALES												
F1	'Mama Moke'												
F3	'Kunaline'												
F4	'Boletina'												
F6	'Pacque'												
4bF	'Mai'												
3bF	'Juillet'												
AdU	Unidentified adults												
SUB-ADULTS													
6aF	'Oeuf de Pacque'												
4cF	'Noel'												
5bF	'Grizmek'												
6bM	'Elikya'												
1bM	'Mpiko'												
4dF	'Minzoto'												
5cM	'Molende'												
3cM	'Solo'												
3aaM	'Bonne Annee'												
1cF	'Nawango'												
3dM	'Mamu'												
5dF	'Jengetu'												
SAU	Unidentified sub-ad												
JUVENILES													
4eF	'Sifa'												
1dM	'Aimeje'												
3eF	'Etumba'												
JU	Unidentified juv.												
INFANTS													
1eF	'Kasi'												
3f	'Aligaru'												
6dF	'Willibadi'												
4da	'Mboliftue'												
TOTAL	INDIVIDUALS												
TOTAL	RHINOS SEEN												
TOTAL	RHINOS IDd												
TOTAL	GROUPS												
Male	adults (MA)												
Female	adults (FA)												
Male	sub-adults (SM)												
Female	sub-adults(SF)												
Male	juveniles (JM)												
Female	juveniles (JF)												
	Infants (I)												

2. EQUIPMENT

Level 1

BINOCULARS

- **Care**
  - no dust
  - no water
  - lens caps
  - do not scratch lenses
  - responsibility of Chef d'Equipe to ensure that each group has at least one pair and that they are passed on to next group or returned to Magasinier if not required.
  - report malfunctioning to magasinier, who must report to GMU for repair or replacement

- **Correct use**
  - remove lens caps
  - adjust width between eyepieces
  - main focus with right eye closed
  - right eye focus with left eye closed
  - replace caps and cover after use

Level 2 & 3

RADIO TRACKING EQUIPMENT

- **Assembly**
  - short cross pieces of antenna at front, long at rear
  - handle
  - coaxial cable between antenna and receiver
- **Care**
  - keep clean and dry
  - keep in bag and dismantle when finished
  - do not leave on unnecessarily, to save batteries
  - flashing light indicates low power, change batteries as shown

- **Operation**
  - start from high point
  - select channel and fine tuning according to code sheet
  - power on as far as necessary
  - hold antenna high and rotate slowly
  - try all channels
  - demonstrate directionality of signal and antenna and nul point
  - decide on signal direction by maximum signal with null point at right angles
  - take bearing and draw on map
  - move to second and if necessary third point, take further bearing and mark on map to estimate position of rhino
  - in relation to wind direction plan approach strategy

Exercises

- Tests with transmitters in known locations
- Field approaches to rhinos

3. COMPLETING OBSERVATION DATA SHEET

DATE, TIME AND OBSERVER

- A single observation of one rhino or a group of rhinos is written along one line on the data sheet

Level 1

- Date is written as DD/MM/YY eg: 10/01/96
- Time is the time when the observation was first made, written in the 24 hour clock eg 14:25. If there is no watch in the group, guess as near as possible, but each monitoring group should ensure that they have a watch before leaving.
- Observers initials should be written in column **Obs.**
- Patrol or recce type, (see list defining types) should be written in column **Pat.**

Level 2

- Follow up observations where a rhino is found as a result of having first been seen by another observer, eg aerial and directions given, should be marked by F in the Notes column.
- Continuum observations, where a later observation follows on from a continuous series, eg re-finding an animal that has run off, should be marked with C in Notes.

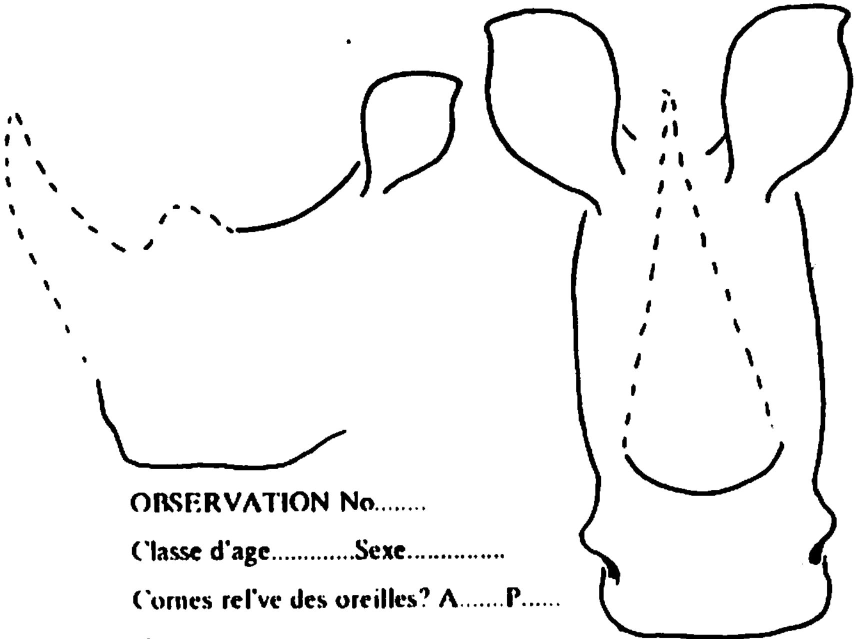
4. MAP READING AND LOCATION

GRID MAP

- The map that has been used for the rhino observations is the 1:278,000 map with a 1x1 km grid marked on it.
- The map ***Fiche de Patrouille*** for the southern sector, with a 5x5 km grid is also included. Every monitoring group should also complete a patrol map like this and general patrol summary, which contributes to the **Law Enforcement Monitoring**

Level 1

- To give basic location by name under **Loc'n**



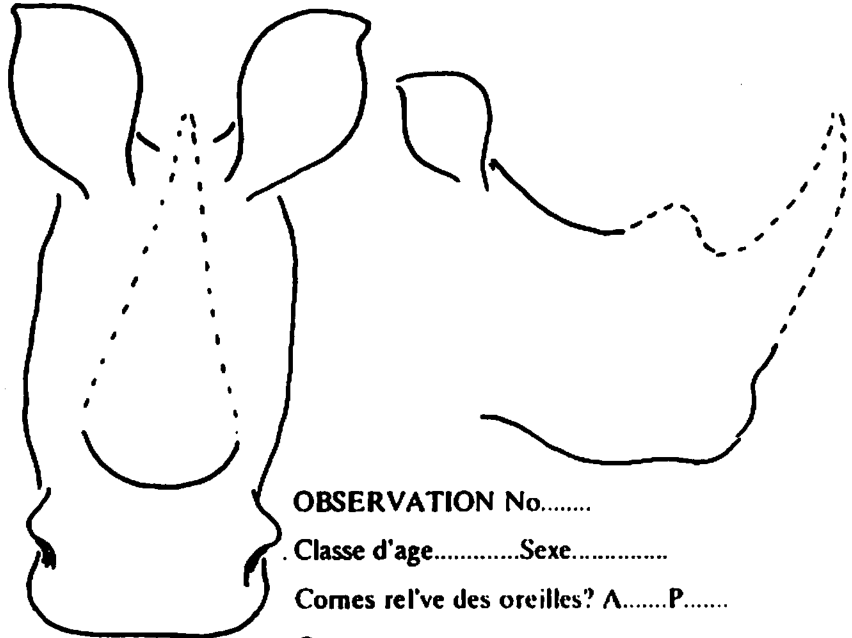
OBSERVATION No........

Classe d'age............Sexe..............

Cornes rel've des oreilles? A.......P......

Queue...............................

ID?.................................



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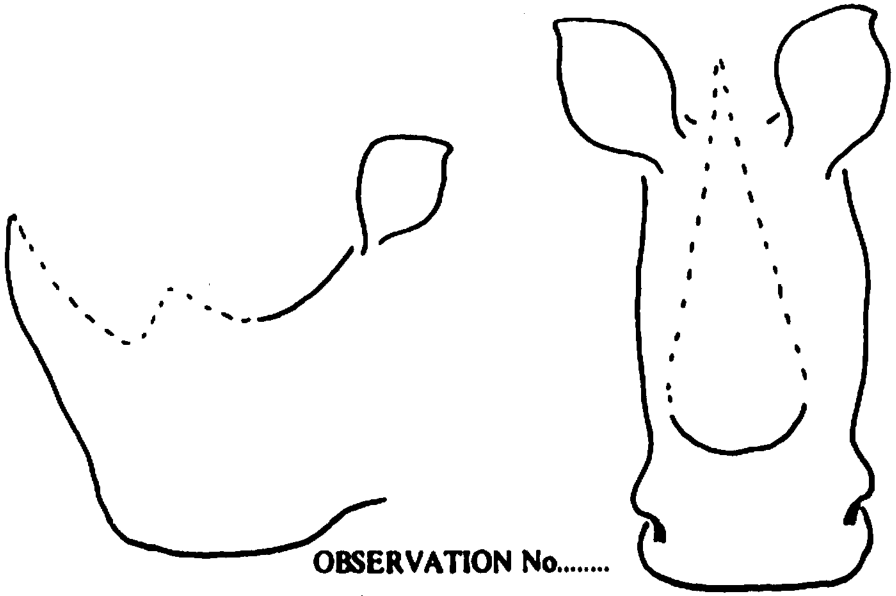

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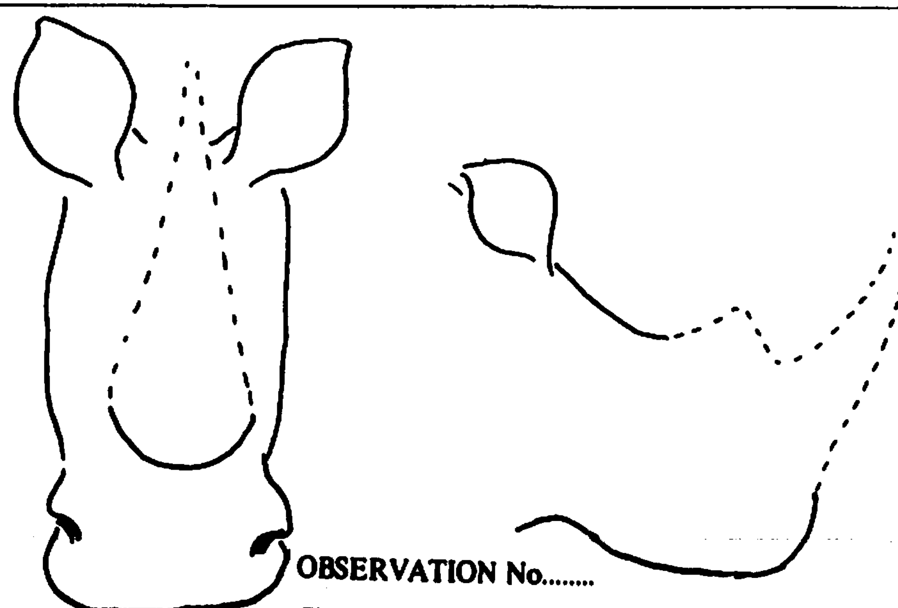

OBSERVATION No........

Classe d'age............Sexe..............

Comes rel've des oreilles? A.......P.......

Queue...............................

Parc National de la Garamba, OBSERVATIONS DES RHINOS MONTH: HABITAT CONDITIONS:

	Date	Time Heure Tango	Loc'n Lieu Esika	Coord- onnnees	No. Tot.	Ad M	Ad F	Ad U	SA M	SA F	SA U	J M	J F	J U	I	Habitat&cond. Ndenge na matiti	Activity Activite Mosala	Assoc.sp Esp.asso Nyama	Individuals , Individus Kenge	Tracks, notes Traces, notes Trace ya kenge	Obs No Obs	Obs type
1																						
2																						
3																						
4																						
5																						
6																						
7																						
8																						
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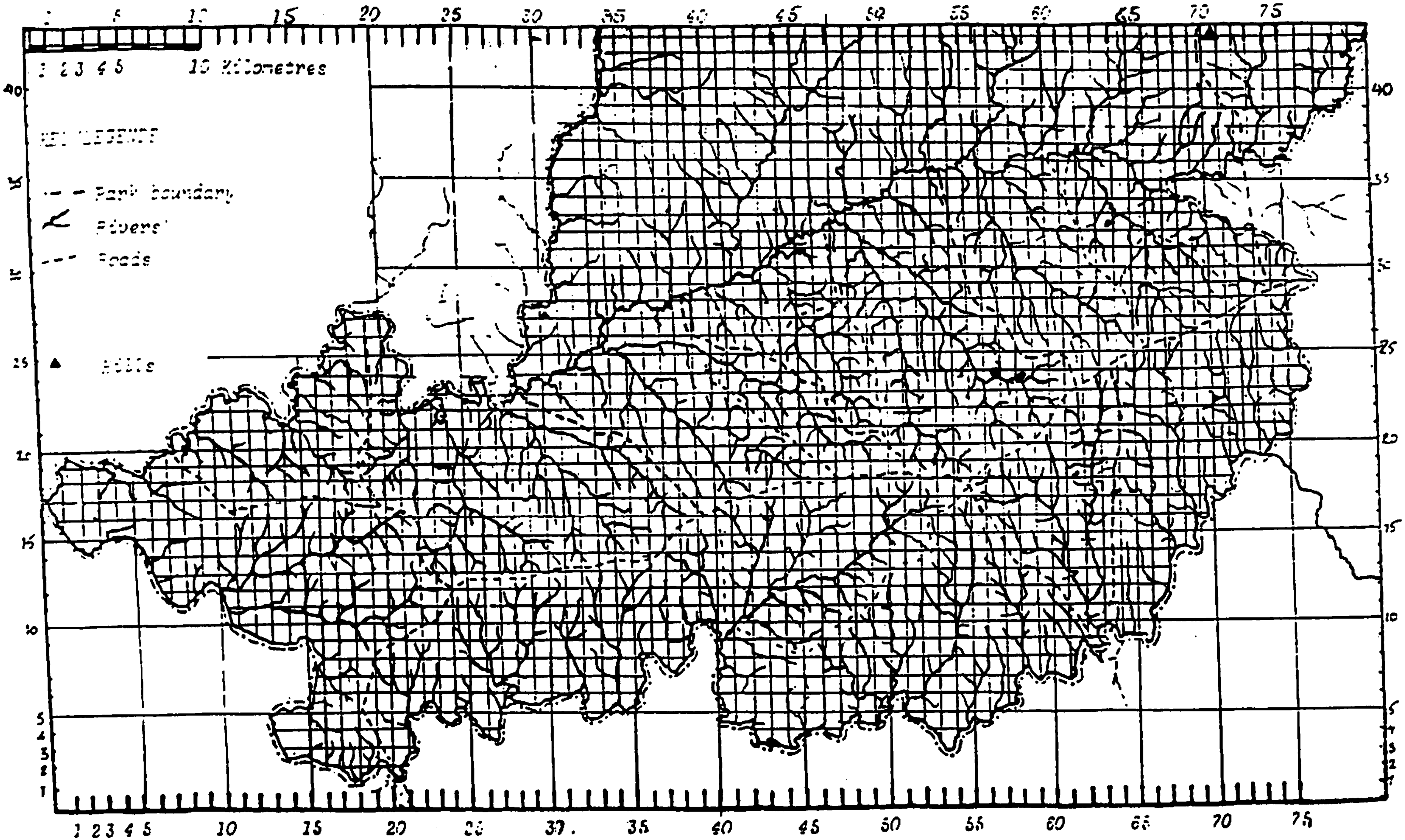


PARC NATIONAL DE LA GARAMBA (Southern sector)

- To be able to give four figure 1x1 km grid square coordinates.

Levels 2 & 3

- Demonstrate map reading ability
- Give 6 figure coordinates using 1x1 km grid.

Exercises

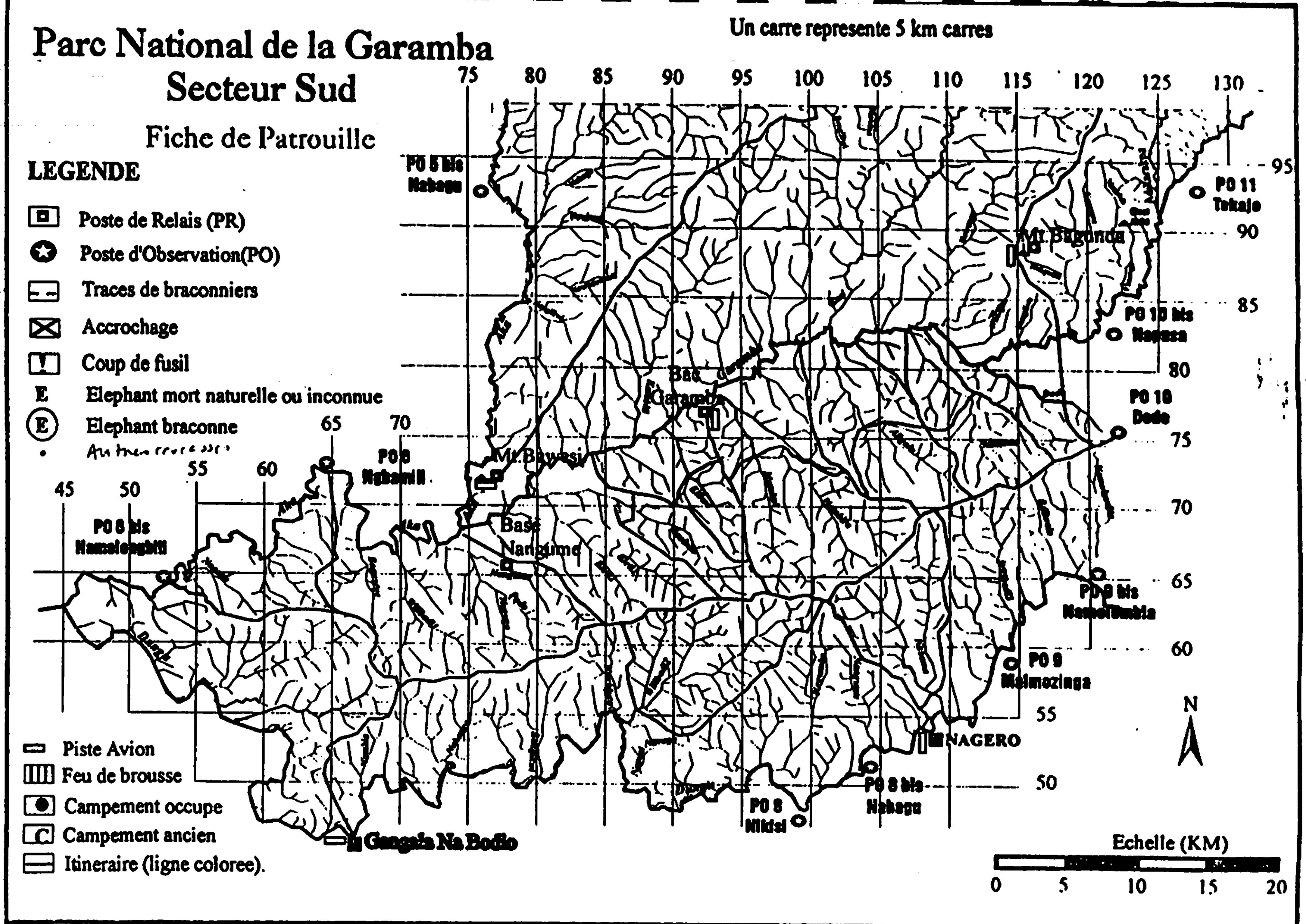
- Demonstrate basic directions N,S,E,W
- Demonstrate scale and grid square sizes
- Find features, 1) Named rivers, 2) road junctions, 3) hills, 4) stations and observation posts.
- Demonstrate coordinates and mark 5 points of supposed rhino locations to be recorded. Find given coordinate positions, eg 352208. 515170, 660274, 092165, 399241 (Source Namvue), 726362 (Gué Garamba)
- Explain reasons for and method of security code for location, based on a random point as a starter, changed each month or patrol. Practice giving security code for each of above coordinates.

COMPASS

- Demonstrate N,S,E,W and relation of these to sunrise & sunset.
- Demonstrate degree markings and relation of these to above.
- Demonstrate taking a bearing, walking that line, and reporting the line (eg for bearing of signal, or gunshot).
- Demonstrate drawing bearing on a map, eg of radio signal from current position.

DISTANCES

- Demonstrate scale on map i.e. 1 square ≡ 1 km x 1 km, 1km = 1000m.
- Estimate distances to points and measure with survey wheel.
- Relate to practical value in field, eg distance to rhinos, flight distances, only counting animals on patrol within 500m


Parc National de la Garamba
Secteur Sud
Fiche de Patrouille
Un carre represente 5 km carres
LEGENDE
Poste de Relais (PR)
Poste d'Observation(PO)
Traces de braconniers
Accrochage
Coup de fusil
E Elephant mort naturelle ou inconnue
Elephant braconne
Piste Avion
Feu de brousse
Campement occupe
Campement ancien
Itineraire (ligne coloree).
PO 5 bis Nabagu
PO 11 Tekaje
Mt Bagunda
PO 10 bis
PO 10 Dodo
Bac Garamba
Mt Bayasi
Base Nangume
PO 8 Ngbamili
PO 8 bis
PO 8 Malmozinga
NAGERO
PO 8 bis Nabagu
PO 8 Nikisi
Gangala Na Bodio
N
Echelle (KM)
0 5 10 15 20

5. AGE AND SEX CLASSIFICATION

All levels

- Total number of rhinos in the group is marked in the total column.

- This total is then broken down to the number of individuals of each sex and age class, which are marked under the appropriate columns.

- **Sex** is distinguished most reliably by being able to see the external openings beneath the tail. The vaginal opening is visible beneath the anus in the female. In the male this is absent, but a fold of skin between the hind legs can be seen. (see diagram). These features can be observed when the animals are standing. When they run away all but the youngest calves curl the tail up over the back, which further facilitates sex determination. Other features give clues, such as the wider horn base of males and the higher length to width ratio of females. An adult with a young calf clearly associated is most likely to be a female, and a lone, well built adult with a wide horn base is most likely to be a male. However, confirmation needs to be based on the features noted above. If the observer is not sure, it is better to use the **Unknown** column.

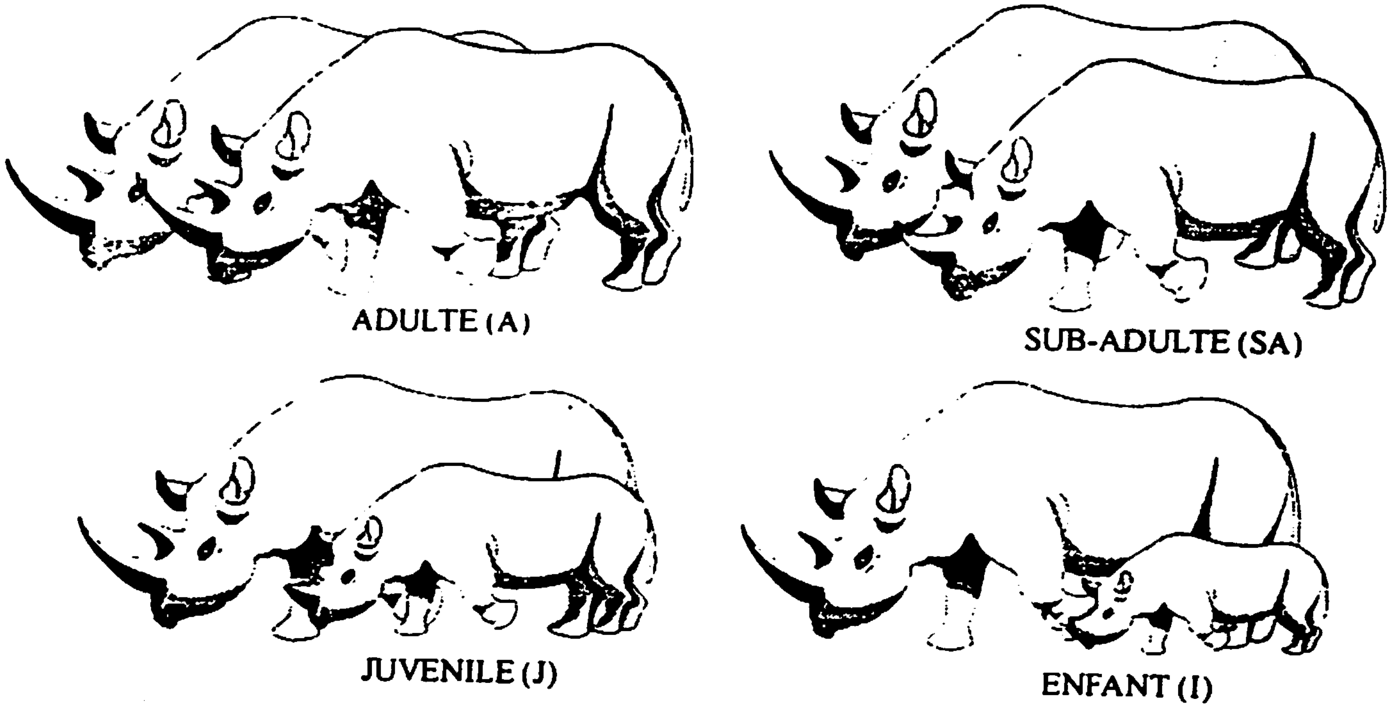
- **Age** is classified as **adult**,(>10 years) **sub-adult** (2.5 - 10 years), **juvenile** (3 months - 2.5 years) **and infant** (0-3 months). The diagram defines size of immature relative to adult, and horn development for each of these age classes. It also defines the ages at which these classes and their sub-divisions change. The development stages are based largely on those noted for southern white rhinos, on the basis of the field work of Owen-Smith (Hillman et al 1982), but with slight modifications in the early stages, where the northern whites appear to pass through some of the stages younger.

- Estimate of horn size relative to ear length is used to aid distinction of different age horns or different individuals. This requires visualising the length of the ear and estimating how many times this can fit into the length of the horn.

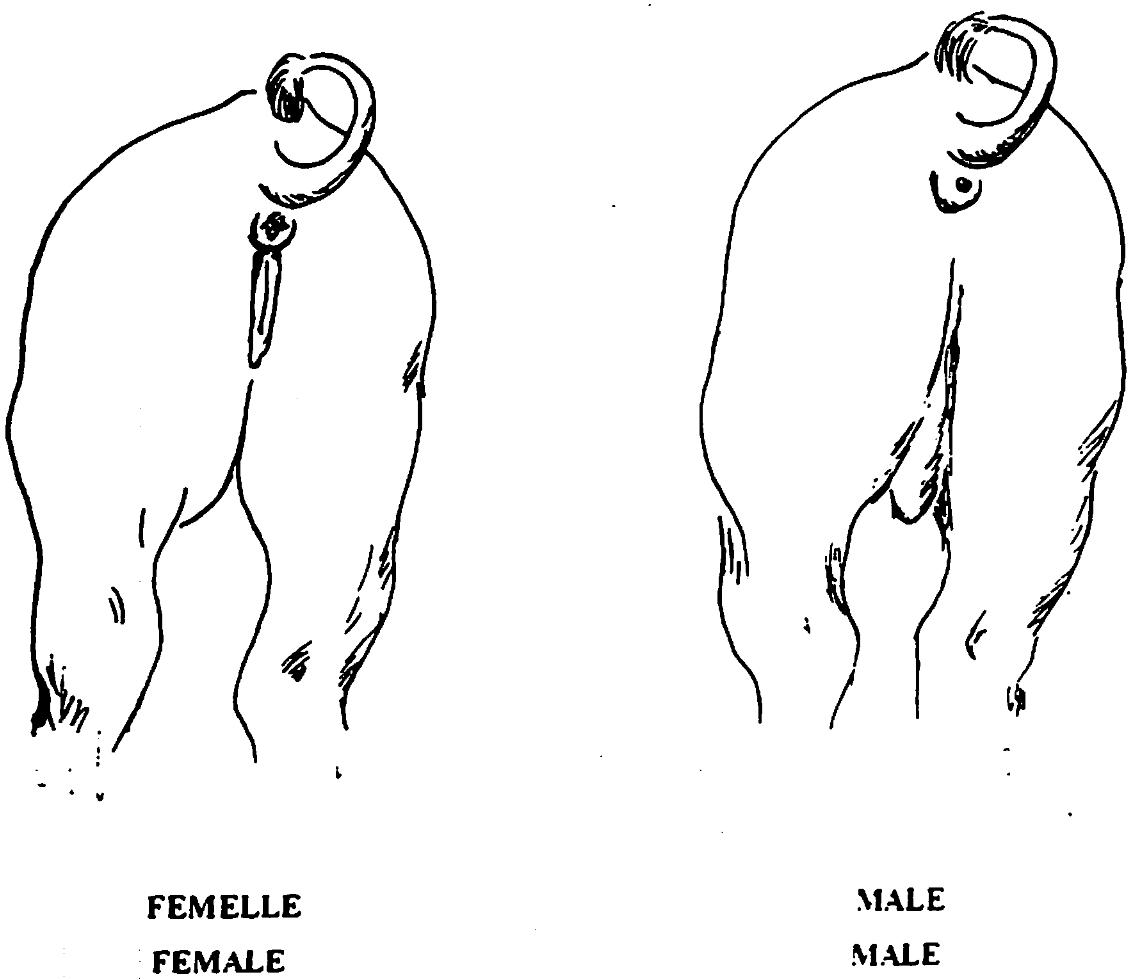
- The sex and age classes combined are then entered on the data sheet. For example if a group contained one adult female, two sub-adult females, one sub-adult whose sex could not be verified and one juvenile male, it would be entered as follows:

T	AdM	AdF	AdU	SAM	SAF	SAU	JM	JF	JU	I
5		1			2	1	1			

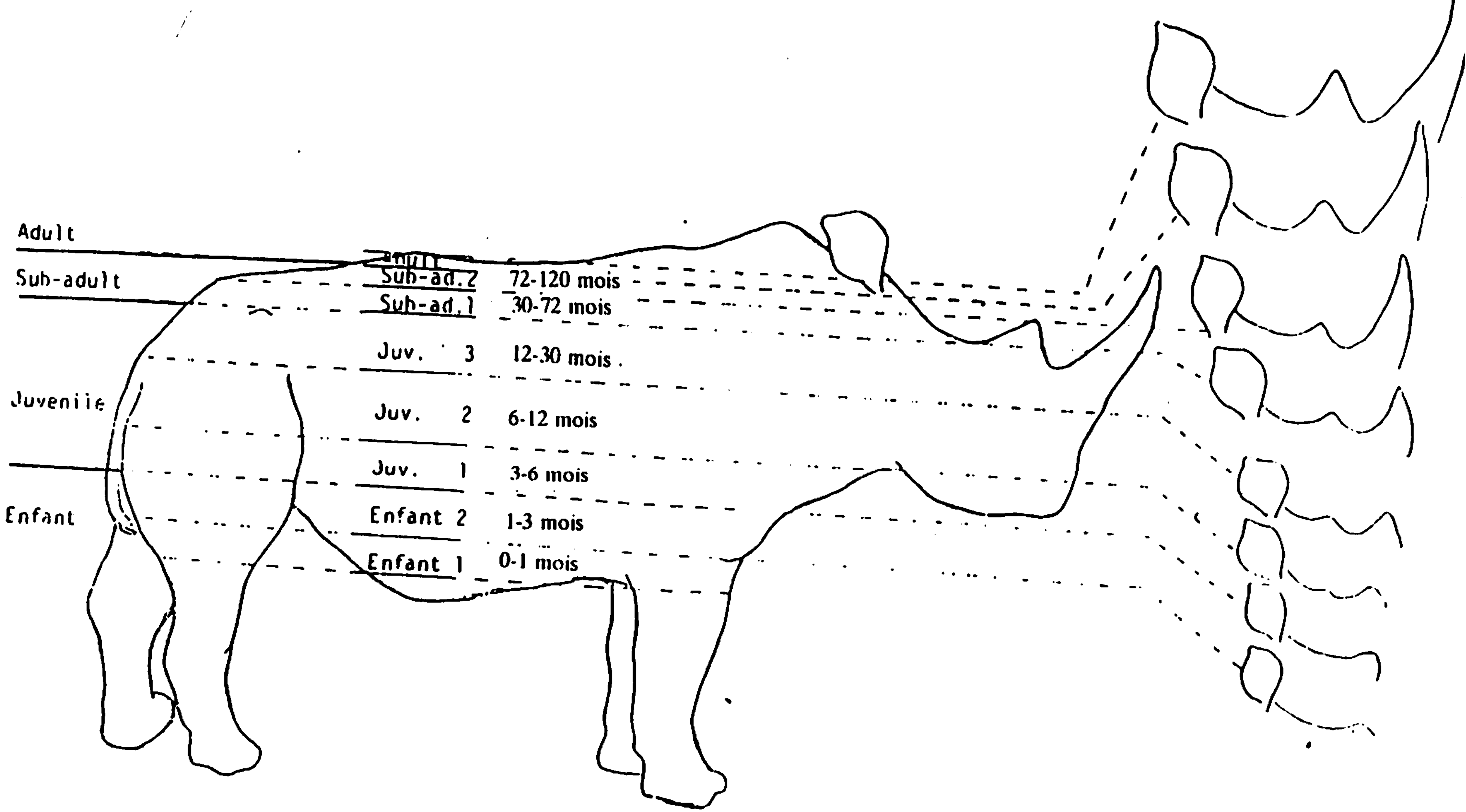
- For each individual a rhino head template should be filled in with a drawing as far as possible of the horn sizes and shapes



Age determination, by size relative to adult/
Determination de l'age par la taille relatif de cela d'adulte



Sex determination / Determination de sexe
Northern white rhinoceros / Rhinoceros blanc du nord



L'hauteur de la jeune relatif a l'hauteur de la mere

Longuer des cornes relatif a longuer des oreilles

DETERMINATION DE L'AGE DES RHINOCEROS BLANCS DU NORD

Exercises

- Slides 1-5 for sex determination

- Practice estimating horn length relative to ear length, on photos, on slides and in the wild, by holding a pencil against the ear and then against the horn. In the wild this can be done by looking past a pencil at the feature.

- Slides 6-12 for age determination, and practice drawing horn shápes and sizes on templates from the slides.

6. HABITAT

All levels to cover, but level 1 not expected to complete full details

- Cover habitat and condition classification (table & diagram) in relation to rhinos in conjunction with slides 1-7, and habitat around training area.

Exercises

- Data sheet entry with slides 1 - 7 and others
- Data sheet entry of rhino observations from air and ground

7. OTHER SPECIES

- Other species are recorded only if they are in some kind of association with the rhinos, not merely if they are nearby or passing. Examples of such association include: Yellow billed Oxpeckers (TBO) collecting ticks off the rhinos and giving warning of danger, Egrets (EGR) follwing the rhinos to collect the insects they disturb, Buffalo (BUF) that the rhinos are resting with or in a group with and whose responses to potential danger alert the rhinos, Elephants (ELE) having an aggresive interaction with rhinos.
- The codes for other species is given on the table following habitats.

CLASSIFICATION DES HABITATS UTILISES PAR DES RHINOS

Niveau 1

TYPES DE VEGETATION

HP Savanne herbeuse des cretes/plateaux
HC Savanne herbeuse des cotes/lisieres des cretes

SA3 Savanne arbustive de faible densité
SA2 Savanne arbustive de moyenne densité

SAR Savanne arborées dominée par *Crossopteryx febrifuga*, par example Km 15.

HV Prairies des vallées

R Riviere

CONDITION

Hauteur
C Courte
MA Moyenne <1metre
MB Moyenne >1metre
LF Longue en floraison
LO Longue et vielle
B Brulée, toujours noir
BF Brulée mais avec repousse des herbes
NZ Nzinga

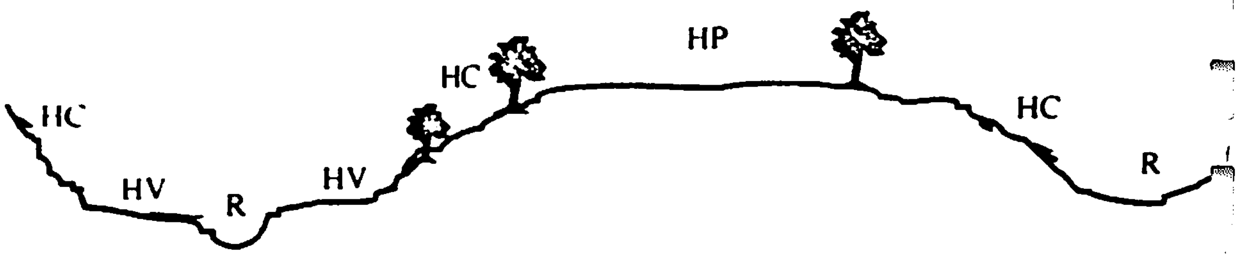
Pourcentage de verduré

G1 0-10%
G2 11-25%
G3 26-50%
G4 51-75%
G5 76-90%
G6 91-99%
G7 100%

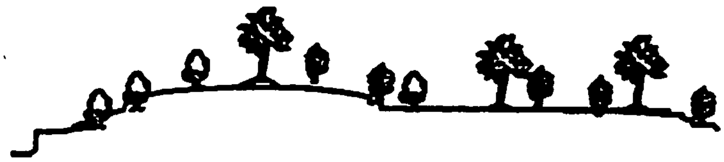
ENDROIT

T Termitière
A Arbre
M Mare
S Source

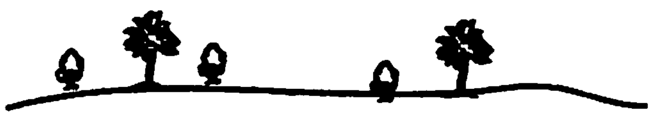
H:



SA2:



SA1:



SAR:

PROFILES DES HABITATS / HABITAT PROFILES

Parc National de la Garamba

CODES DES ESPECES

CODE	*NOM FRANCAIS*	*ENGLISH NAME*
ELE	Elephant	Elephant
RHI	Rhinoceros	Rhino
HIP	Hippopotame	Hippo
COB	Cobe de Buffon	Kob
BUF	Buffle	Buffalo
GIR	Girafe	Giraffe
BUB	Bubale	Hartebeeste
WAT	Waterbuck	Waterbuck
ROA	Antelope rouane	Roan antelope
RED	Redunca	Reedbuck
ORI	Ouribi	Oribi
GUI	Guib harnache	Bushbuck
CEG	Cephalophe Grimm	Grey duiker
CEJ	Cephalophe à dos jaune	Yellow-backed duiker
CER	Cephalophe à flancs roux	Red-flanked duiker
ELA	Eland de Derby	Eland
SIT	Sitatunga	Sitatunga
PHA	Phacochere	Warthog
HYL	Hylochere	Giant forest hog
POT	Potamochere	Bushpig
LIO	Lion	Lion
HYE	Hyene	Hyena
LEO	Leopard	Leopard
BAB	Babouin	Baboon
SIC	Singe Colobe	Black and White Colobus
SIP	Singe Patas	Patas monkey
SIB	Singe de Brazza	de Brazza's monkey
SIV	Singe vervet	Vervet monkey
CRO	Crocodile	Crocodile

Carcases ou des os d'éléphant, ou d'autres éspeces

Registrez l'éspece comme ES:Squellete d'éléphant, BS:Squellete de buffle US:Squellete pas identifié etc

1	Carcase fraiche	Fresh carcase
2	Os recent avec aire de pourriture	Recent bones with rot patch
3	Os blanc sans pourriture	White bones without rot patch
4	Os gris	Grey bones

Signes humains

VAC	Vaches	Cattle
SHO	Chevres/moutons	Shoats
MAH	Maison d'habit'n	Living hut
MAA	Maison abandonnée	Abandoned hut
ASH	Ancien site d'habitation	Old living site

Sous notes classifiez tous les trois au-dessus comme partie du village ou famille, et en route ou en sentier.

RTE	Route	Road
SEN	Sentier	Footpath
CBO	Campement braconniers occupé	Poachers'camp,occupied
CBR	Campement braconniers,recent	Poachers' camp, recent
CBA	Campement braconniers ancien	Old poachers camp
PEC	Peche	Fishing
MIN	Mine	Mine
MIA	Mine abandonné	Abandoned mine

Parc National de la Garamba

CODES DES ESPECES

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BUB	Bubale	Hartebeeste
WAT	Waterbuck	Waterbuck
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RED	Redunca	Reedbuck
ORI	Ouribi	Oribi
GUI	Guib harnache	Bushbuck
CEG	Cephalophe Grimm	Grey duiker
CEJ	Cephalophe à dos jaune	Yellow-backed duiker
CER	Cephalophe à flancs roux	Red-flanked duiker
ELA	Eland de Derby	Eland
SIT	Sitatunga	Sitatunga
PHA	Phacochere	Warthog
HYL	Hylochere	Giant forest hog
POT	Potamochere	Bushpig
LIO	Lion	Lion
HYE	Hyene	Hyena
LEO	Leopard	Leopard
BAB	Babouin	Baboon
SIC	Singe Colobe	Black and White Colobus
SIP	Singe Patas	Patas monkey
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CBA	Campement braconniers ancien	Old poachers camp
PEC	Peche	Fishing
MIN	Mine	Mine
MIA	Mine abandonné	Abandoned mine

8. ACTIVITY

Level 1

- Write activity as observed

Levels 2 & 3

- Activity in **Activity** column as coded:

MAN	Manger	Feeding
MAR	Marcher	Walking
DEB	Debut	Standing
DAL	Debut alert	Alert, standing
BOI	Boire	Drinking
REP	Repos	Resting
COU	Courir	Running
FRO	Frotter	Rubbing, horn or body
VAU	Se Vautrier	Wallowing
TET	Teter	Suckling
PAS	Parade sexuelle	Courtship
PAG	Parade aggressive	Aggressive display
COM	Combat	Fighting
VOC	Vocalisation	Vocalisation
DOR	Dormir	Lying (does not necessarily mean sleeping, though it usually is. This code was used to distinguish between COUcher: lying and COUrir: running)
URI	Uriner	
PIC	Pictiner	

Exercises

- Slides 8-14, and field observation

9. IDENTIFICATION OF INDIVIDUALS

Levels 2 & 3

- Features used for individual identification:
  Horn shapes (change over time, need to keep frequent track of them)
  Ear marks, both natural and cut; Tail losses;
  Nose wrinkles, at close quarters.

- ID cards for each rhino, with details and photos of most exist and centralise information for each individual, but they are heavy, and the summary ID sheets in the manual are used on patrol.

- All founder adults at the start of the project are called F(female) or M (male) plus a number. All offspring of any one female take her number plus a letter a,b,c, etc to indicate their order of birth, then a suffix F or M to indicate sex. Each animal also has a name. Eg. F1 "*Mama moke*" was the first adult female named. 1cF "*Nawango*" is F1's third calf and is female.

- Go through all IDs with the ID sheets and background on their home ranges and associations.

- Confirmed IDs for the group are written under the column **Individuals** and must have a drawing on the template on reverse of form to indicate features leading to the identification.

- Field observations and identifications must be accompanied by a drawing on the rhino template of ear marks, horn shapes, tail or other marks and ideally nose wrinkles.

Exercises

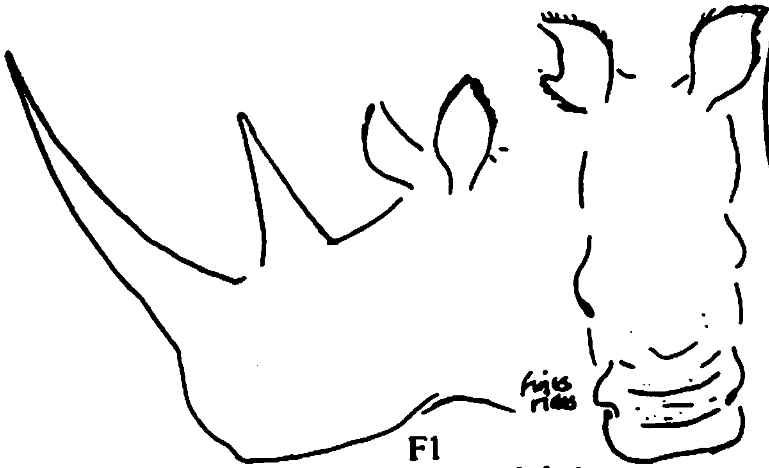
Transparencies are particularly valuable here, because looking through a magnifying lens then back to the paper simulates looking through binoculars and then down to the data sheet and trains the memory.

- From drawings and photographs practice identifying individuals.

- Slides 13-18 for identification. Draw template first, then work out identification

- Slides 13-18 for full completion of forms

- Field observations with trainer



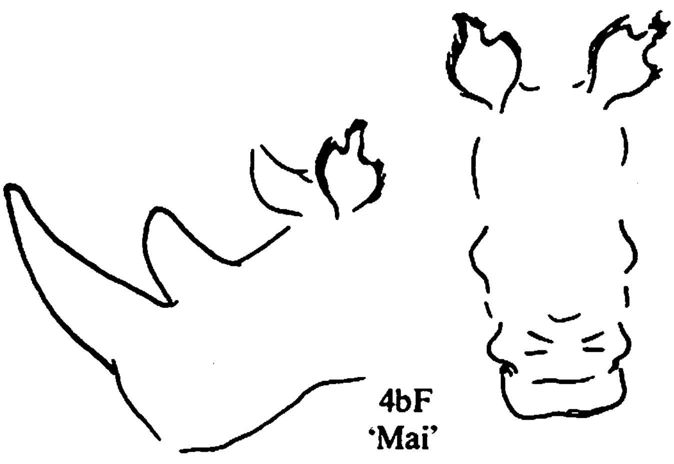
F1
'Mama Moke'

F3
'Kunalina'

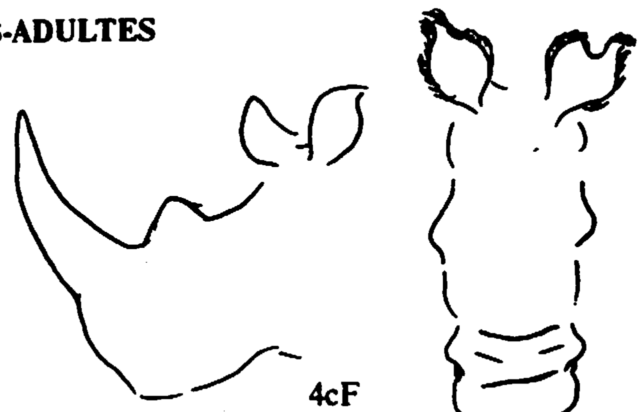
F6
'Pacque'

F4
'Boletina'

SUB-ADULTES

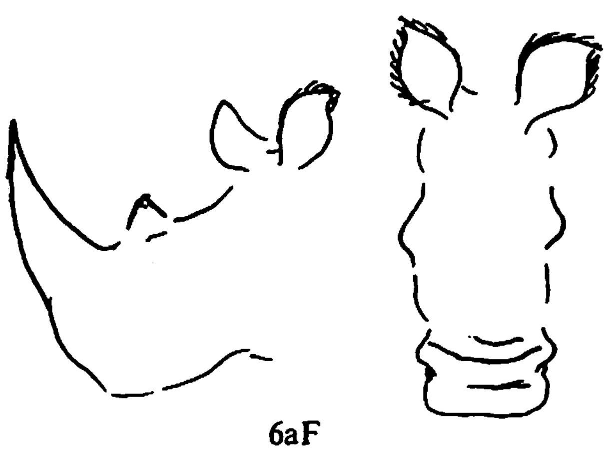


4bF
'Mai'



4cF
'Noel'

4dF
'Minzoto'

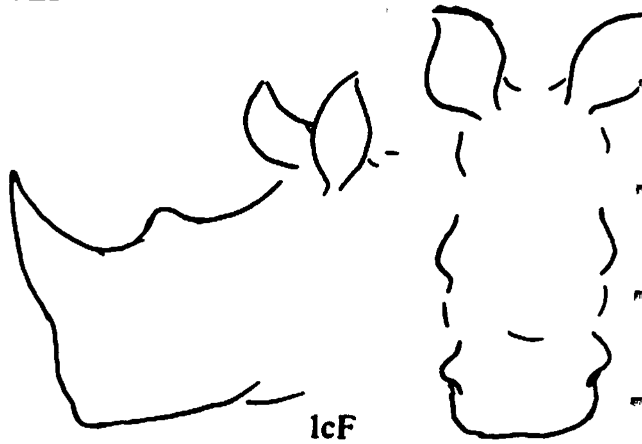


6aF
'Oeuf de Pacque'

FEMELLES

SUB-ADULTES

5bF
'Grizmek'



1cF
'Nawango'

5dF
'Jengatu'

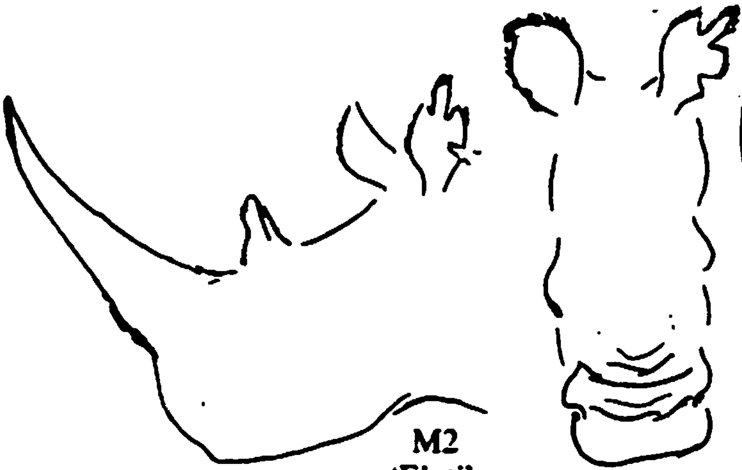
3eF
'Etumba'

JUVENILES

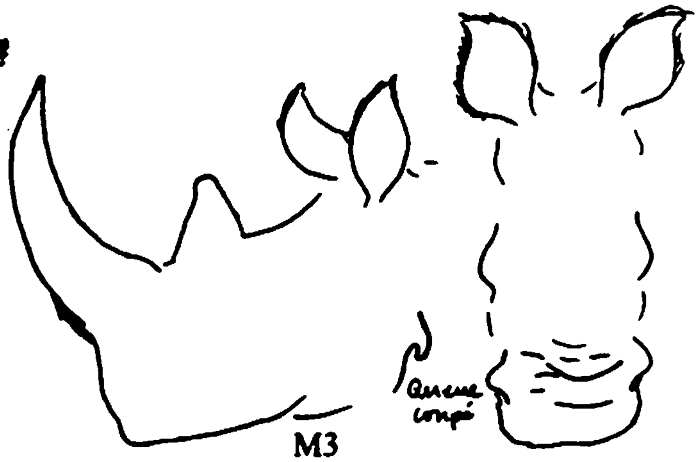
1eF
'Kasi'

3f
'Aligaru'

FEMELLES



M2
'Eleti'



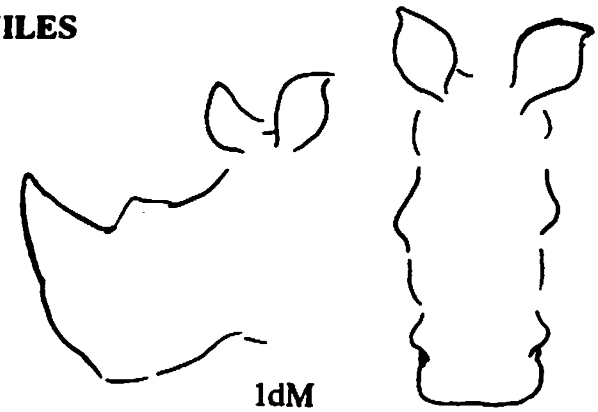
M3
Kondo akatani'

M4
'Bac'

M9
'Notch'

JUVENILES

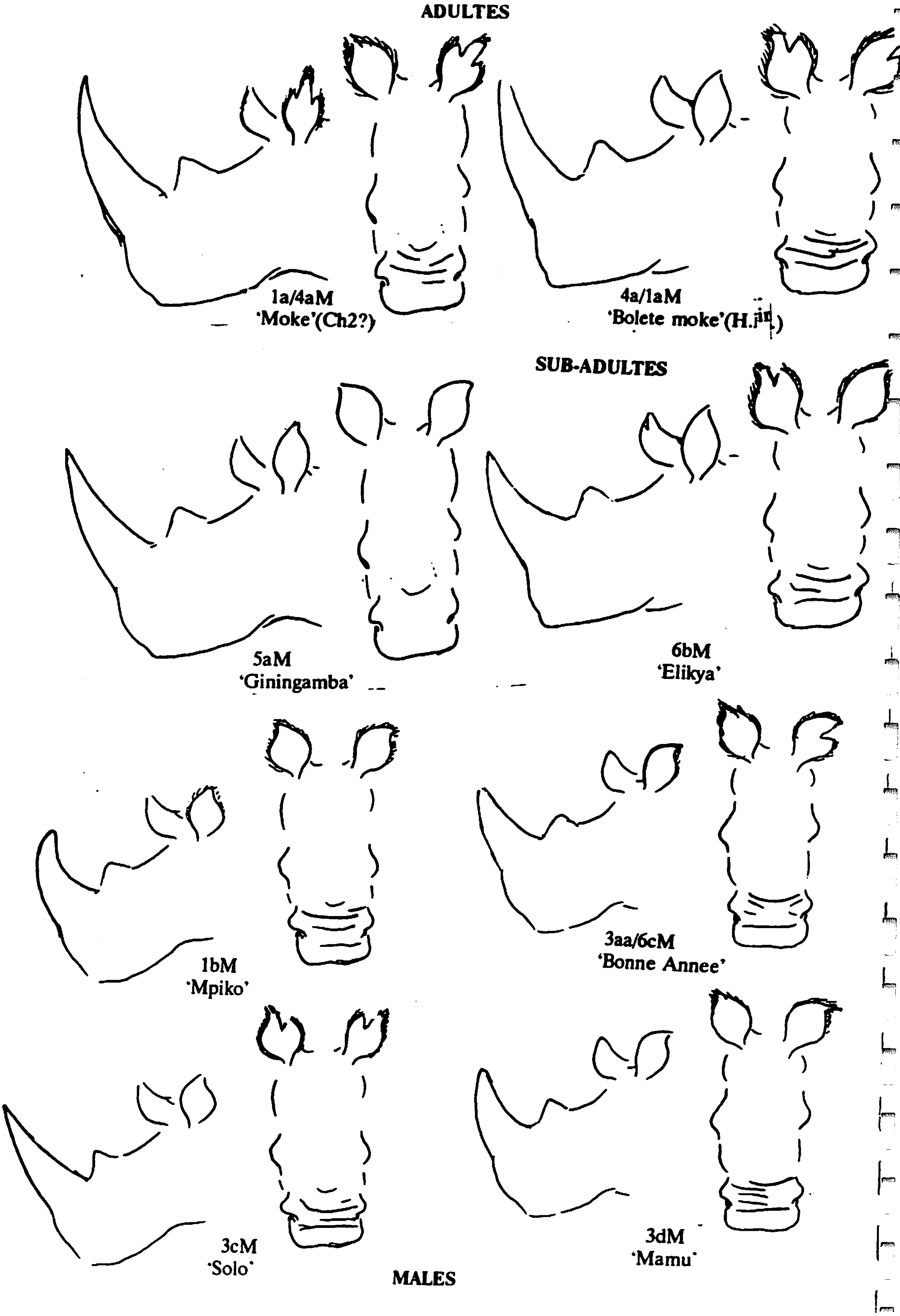
4e
'Sifa'

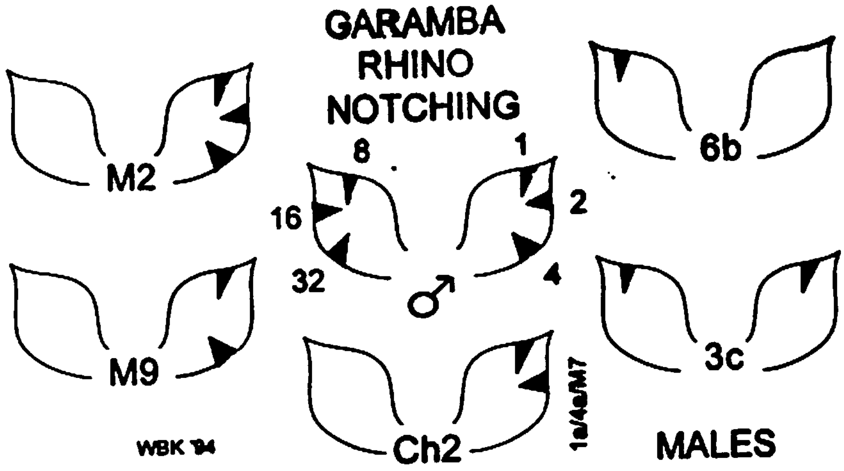


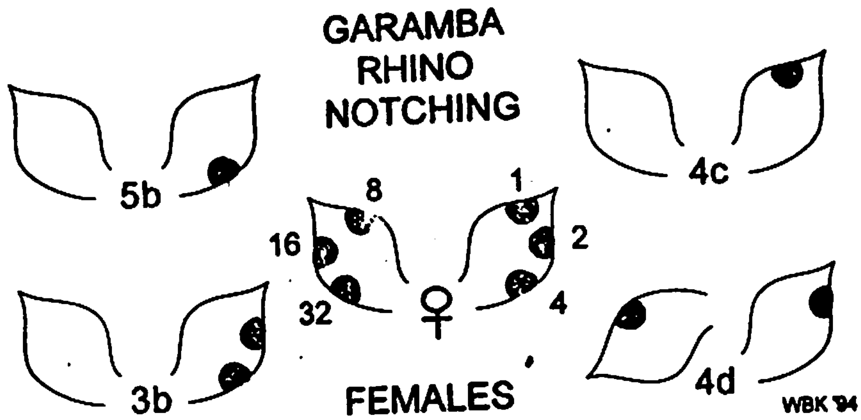
1dM
'Almeje'

6d
'Willibadi'

MALES


ADULTES
1a/4aM
'Moke'(Ch2?)
4a/1aM
'Bolete moke'(H.jin)
SUB-ADULTES
5aM
'Giningamba'
6bM
'Elikya'
1bM
'Mpiko'
3aa/6cM
'Bonne Annee'
3cM
'Solo'
3dM
'Mamu'
MALES





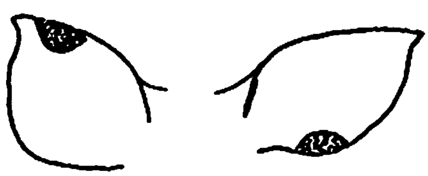
SAM
3aa/6c
Bonne Annee

Ch.
05
+5

AdM
H.E.
Hairy Ears

15
+3

SAF
3e
Etumba



25
+2

AdF
4b
Mai

35
+35

45
+2

SAF
5d/1c
Jengatu

Parc National de la Garamba

NORTHERN WHITE RHINOCEROS (*Ceratotherium simum cottoni*) POPULATION STRUCTURE, JUNE 1996

ID	Name	STATUS	AGE GUESS	LAST SEEN
ADULT MALES				
M2	'Eleti'	dominant.	Age >25	6.96
M3	'Kondo akatani'	dominant since 09.88	Age +-17	5.96
M4	'Bac'	probably dominant.	Age >20	5.95
M5	*'Bawesi'*	*dominant*	Age >20	Poached 2.96
M6	*'Longuecorne'*	*dominant*	Age >30	92
M7	*'Moitier'*	*young male*	Age +-15	92
M9	'Notch'	dominant	Age >19	6.96
1aM	'Moke'(Ch2?)	S2, male, born mid 1983		2.96
4aM	'Bolete moke'(H.E.)	S2, male, born c. 08-09.1983		6.96
5aM	'Giningamba'	S2, male, born 02.85		3.96?
ADULT FEMALES				
F1	'Mama Moke'	with J	Age >20	6.96
F3	'Kunalina'	with J	Age >19	6.96
F4	'Boletina'	with S	Age >19	6.96
F5	*'Mama Giningamba'*		Age >18	Died nat. cause 1.95
F6	'Pacque'	with J	Age >19	6.96
3aF	*'Kuni'*	*born c.9-10/83.*		92
4bF	'Mai'	female, born 05.85		6.96
3bF	*'Juillet'*	*female, born 07.85.*		Poached, pregnant 3.96
6aF	'Oeuf de Pacque'	female, born 03.86		6.96
SUB-ADULTS				
4cF	'Noel'	S2, female, born 10-11.87 (M2 sire ?)		6.96
5bF	'Grizmek'	S2, female, born 10.87 (M4 sire?)		9.95
6bM	'Elikya'	S2, male, born 06.88		6.96
1bM	'Mpiko'	S1, male, born 03-04.89		6.96
4dF	'Minzoto'	S1, female, born 08-09.89, with I		6.96
5cM	*'Molende'*	*S1, male, born 08.89 (M3 sire?)*		Died 3.93
3cM	'Solo'	S1, male, born 12.89,		1.96
3aaM	'Bonne Annee'	S1, male, born 12.90 (M6 sire?)		6.96
1cF	'Nawango'	S1, female, born 02.91		6.96
3dM	'Mamu'	S1, male, born 09.91		5.95
5dF	'Jengatu'	S1, female, born 07.91 (M3 sire?)		6.96
4eF	'Sifa'	S1, male, born 01.92		6.96
1dM	'Almeje'	S1, male, born 6.93		3.96
3eF	'Etumba'	S1, female, born 7.93		6.96
JUVENILES				
1eF	'Kasi'	J2, female, born 8.95		6.96
3f	'Aligaru'	J1, female 9.95		6.96
6dF	'Willibadi'	J1, male born 9.95		6.96
INFANTS				
?M	*'Kenge moke'*	*I1, male, born c.12.2.93*		Died 15.2.93
4f	*'Nauloko'*	*I1, born 01.94*		Presumed died 2-3.94
4da	'Mbolifué'	I1, born 6.96		6.96

TOTAL KNOWN INDIVIDUALS	
Male adults (MA)	7 + 2 poss
Female adults (FA)	6 + 1 poss
Male sub-adults (SM)	7
Female sub-adults(SF)	6
Male juveniles (JM)	1
Female juveniles (JF)	2
Infants	1
TOTAL	30 + 3 possible
SEX RATIO	15M : 14F,
ADULT:SUBAD.+ JUV.RATIO	1 : 1.3

Level 3

10. DETAILED OBSERVATIONS

The *Fiche d'Activité des Rhinos* forms a useful basis for data collection in a standard way by the researchers and guards trained to level 3. These data contribute to the feeding and behaviour studies and motivate the guards to remain with the rhinos for extended periods, contributing to their protection, and increasing our understanding of them and the guards' interest and identification with them. General notes in field notebooks are also useful, but the structured data collection during long term observation is preferred both by the observer and the analyst and reduces a major data extraction step.

From it feeding observations can be summarised onto the *Fiche des observations de la nourriture* and activity data onto the *Sommaire des Activites*.

ACTIVITY/BEHAVIOURAL CHANGES

- In the section of columns labelled **Activite**, put the identity of each individual at the head of a column in **ID**. That column then refers to the activity for that individual at any point in time. Each time there is a major change in activity of an individual, mark the time in the **Heure** column and the activity for each individual beneath its column in the **ACT** block.

- **Direction relative to wind** is marked in the **DIR** column. In each case, imagine the wind is coming directly at the observer (N-S down the page) the orientation of the rhino is marked as an arrow relative to that.

- **INI ACT** is the individual initiating each change in activity.

- **HABITAT** is the habitat the rhinos are occupying, and its condition, as in the Habitat Classification sheet.

- **LIEU** is the micro-habitat within it, eg termitaria, beneath tree, as in Endroit on the Classification.

- **Distance** between individuals is recorded for each line of observation. At the head of each column two individuals are marked. The distance below, in metres is the distance estimated to be between them.

- More detailed notes are written in the **NOTES** section at the side.

Exercises

- Slides 7-9 for behaviour,

- Experiment estimating and measuring distances between people

- Slides 1-6 for distances

- In-field practice

SOMMAIRES DES ACTIVITIES

This form is used to summarise observations of activities recorded either on the **Fiche d'Activité** or in field notebooks.

- One block is for each individual, identified in **IDENT.**
- **HRE DEB/FIN** refers to the start and end times of the observation.
- Within each 3 hour time period, the total time spent by that individual on each of the activities marked in the **ACTIVITE** column. Other activities can be added in the blank spaces.
- The total of all the activities for any given time period should equal the total time of observation during that period.

OBSERVATIONS DE LA NOURRRITURE

These forms can be completed directly for specific feeding observations, or extracted from the **Fiche de l'Activité** or field notebooks.

- One form is used for each individual, so **IDENT** is only written once for each series.
- **HRE** refers to the time that the rhino enters the habitat or micro-habitat, which is itself entered under **HABITAT,** and its condition under **COND**
- **HRE ACT** is the time that an activity changes and **ACT** is the activity. **MIN** is the total number of minutes spent on that activity in that habitat.
- **ESP.MAN.** are the species eaten, if this can be seen, and **TOUFES ET FREQ.** are measures of selection in terms of numbers of bites, if it is possible to see that, or number of tufts of each species grazed when viewing the area after the rhino has moved on. These latter two columns are difficult and can only be accurately recorded under ideal circumstances. They are not essential.

SOMMAIRES DES ACTIVITES DES RHINOS

DATE	IDENT	HRE DEB/FIN	ACTIVITE	Totales des minutes a chaque activite dans chaque periode d'observation			
				0600-0900hrs	0900-1200hrs	1200-1500hrs	1500-1800hrs
			Totale				
			MAN				
			DOR				
			DEB				
			MAR				
			Totale				
			MAN				
			DOR				
			DEB				
			MAR				
			Totale				
			MAN				
			DOR				
			DEB				
			MAR				

OBSERVATIONS DE LA NOURRITURE DES RHINOS

DATE	IDENT	HRE ENTRE	HABITAT	CONDITIO	HRE ACT	MIN.	ACT.	ESPECE MAN	TOUFES ET FREQ

11. COLLECTION OF FAECAL MATTER

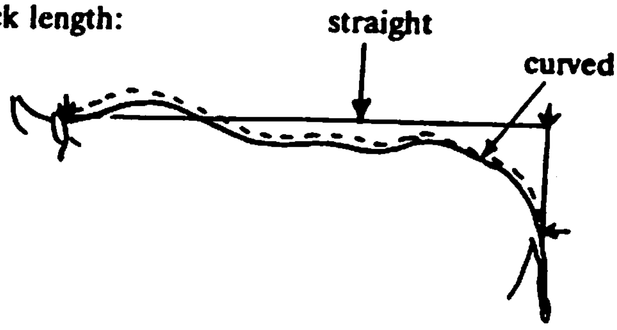
Fresh rhino faecal matter can be collected in conjunction with the feeding study, and if it is fresh and from known individuals it is collected for genetic analysis.

- For food analysis, a sample consisting of small samples from five different parts of the dungpile from one animal is collected into glacial acetic formaldehyde.
- For genetic analysis, it is collected, without touching it by hand, into absolute or 90% alcohol.
- For both, label with date, location, habitat, individual, age and sex (if known), collector and whether from a midden or single pile.

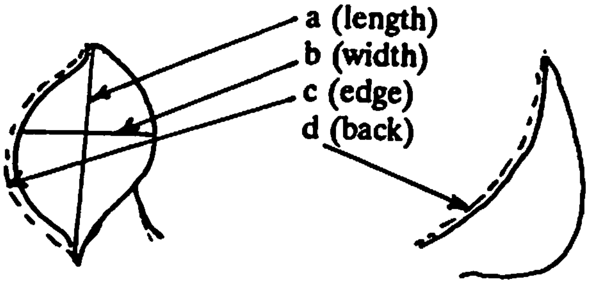
12. RHINO MEASUREMENTS

BODY MEASUREMENTS

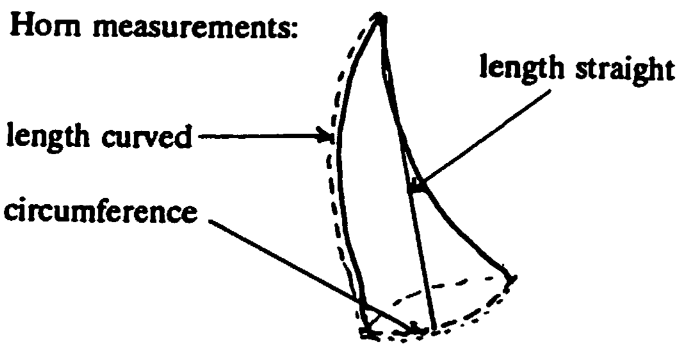
- Immobilised rhinos are measured according to the following data sheet.
- Back length:



- Ear meaurements:



- Horn measurements:



- Foot measurements follow the instructions for measurement of tracks
- Positions of skull measurements are drawn and described, following the standard laid out by the African Rhino Specialist Group, (du Toit,R. 1986 Re-appraisal of Black Rhino Sub-species, Pachyderm 6;5-9)

Parc National de la Garamba

RHINO MEASUREMENTS/DIMENSIONS DE RHINO (Ceratotherium simum cottoni)

(cm)

DATE................ No...................... NAME/NOM... CH..........

AGE/SEX...................... GRP.................... LOC..

SHOULDER HT/HAUT.EP.(lat.rec.)................................ (standing/debut)..

BACK LENGTH/LONGEUR DOS (st./droite)........................ (curved/courbe).. TAIL..........

GIRTH/AU TOUR CORPS......................... NECK CIRC/CIRC.DE COU...

HEAD LENGTH(betw.ears-base horn)...................(-lip)...... DORS.CONC..............P-O.WIDTH...................

EAR/OREILLE a(.).......................b(w)........................c(edge)..................d(back)..............................

HORN/CORNE.ANT(l.st)....................(l.curved)......................b.circ...

HORN/CORNE.POST(l.st)....................(l.curved)......................b.circ...

FOREFOOT/PIED ANT(l).............(mi.l)..................(w).................(circ).............................

HINDFOOT/PIED POST(l).............(mi.l)..................(w).................(circ).............................

TOOTH MEAS./DIM.DES DENTS (impr..........direct.......) CLASS........................

HT. pm1......pm2......pm4......PM2.......PM3......PM4......M1......M2......M3......

WIDTH. pm1....pm2....pm4....PM2....PM3....PM4....M1....M2....M3....

WEAR. pm1....pm2....pm4....PM2....PM3....PM4....M1....M2....M3....

EAR NOTCHES/COUPS D'OREILLES STORAGE TO

NOSE WRINKLES/ RIDES DU NEZ

OTHER CHARS./ AUTRES CHARS.

HORNS/CORNES

TELEMETRY TYPE & FREQ.

CHANNEL

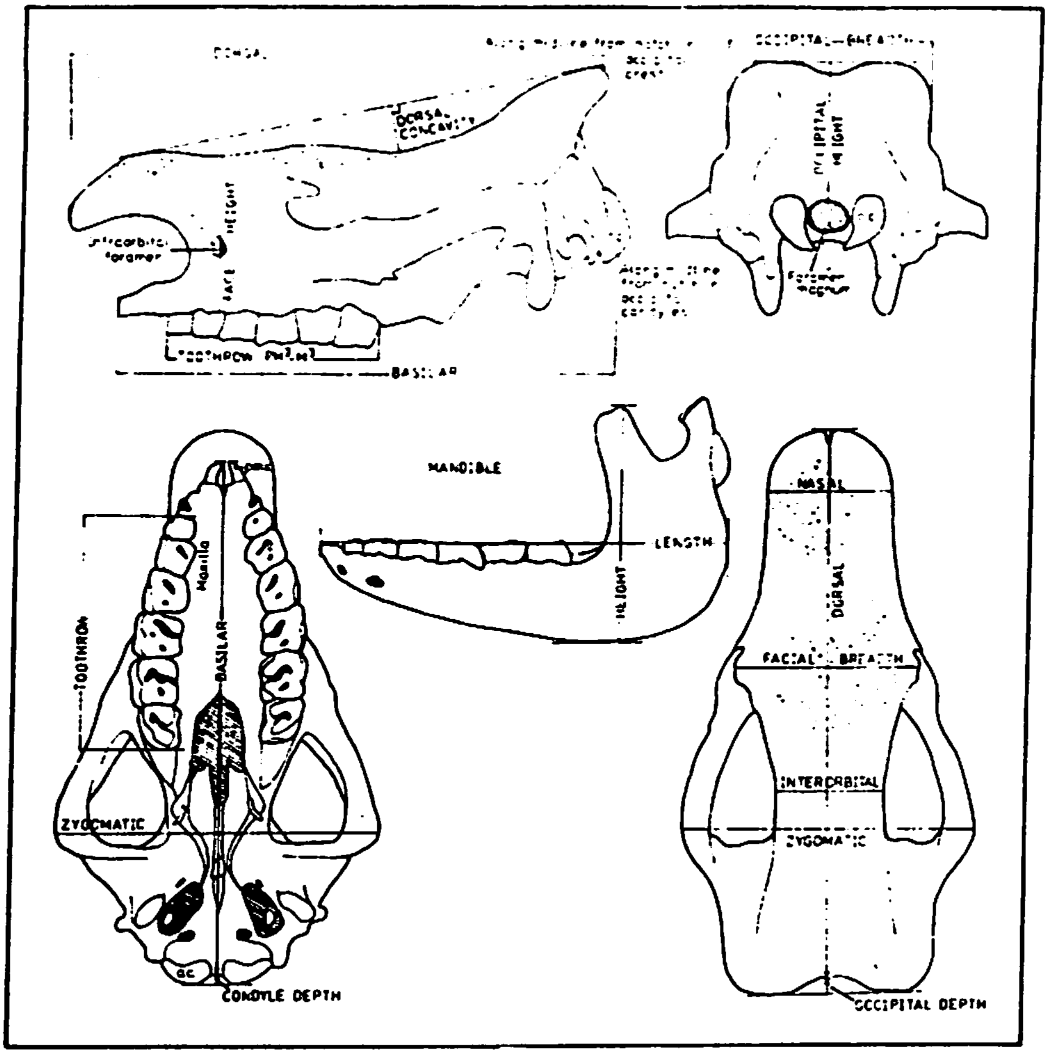
TRANSPONDERS (no.)

(position)
Neck
Post horn

SAMPLES
Blood
Tissue
Ticks
Faeces
Other

TO

NOTES



SKULL MEASUREMENTS

Measurements should be in millimetres whenever possible; they can be made quite accurately with a steel tape and a couple of rulers, set-squares or straight planks.

Figure 3 shows the various measurements that are required. Most of these are standard for this type of work on skulls (e.g. von den Driesch, 1976), but since some slightly different measurement techniques may have been used by other researchers, additional measurements ("occipital depth"; "condyle depth") are included to cover all possibilities. Essential measurements are indicated with an asterisk.

- **Toothrow Length** can be measured on either side (in the cranium, not the lower jaws) and is of six teeth only; it does not include the first premolar, which is often absent anyway. The measurement is from the anterior edge of the second premolar to the posterior edge of the last molar.

M^2 Height is from the anterior crest on the buccal (cheek) side of the second upper molar to the bone directly below; if a gumline is still visible on the tooth, a second measurement can be made from the crest to this line. These measurements are not absolutely essential but it would be useful to have these data to relate them to the tooth wear index.

- **Basilar Length** is the distance from the front lower border of the foramen magnum to the front edge of the premaxilla. If the premaxilla are missing (which has to be checked since these delicate bones do tend to break off) then the measurement should be to the most anterior points of the maxilla, with a note to this effect.

Condyle Depth is the distance from the posterior edge of the occipital condyles to the front lower border of the foramen magnum.

- **Dorsal Length** is a midline measurement from the rim of the occipital crest to the front of the nasals. Sometimes there is a bump in the centre of the occipital crest, but the measurements should nonetheless be taken on the midline, including this bump.

Occipital Depth is the depression between the wings of the occipital crest, measured horizontally on the midline of the skull (i.e. an extension of the dorsal length).

- **Zygomatic Breadth** is the greatest width of the skull.
- **Interorbital Breadth** is the narrowest distance between the orbits.

Facial Breadth (anterior interorbital breadth) is the width across the roughened area that bears the posterior horn. This appears to be a particularly variable dimension, possibly with little statistical significance, because of the very irregular growth of bone on either side of the skull in this area.

- **Nasal Breadth** is the width across the roughened nasal boss that bears the anterior horn.

Face Height is measured from the rim of the tooth sockets perpendicularly across the infraorbital foramen to the upper surface of the nasals.

- **Dorsal Concavity**: place a ruler or flat plank on top of the skull, along the midline, so that it rests on the nasal boss and the centre of the occipital crest. The maximum perpendicular distance between this plane and the concave surface of the cranium (between the orbits) is then measured.
- **Occipital Breadth** is the greatest breadth across the back of the braincase.
- **Occipital Height** is measured vertically on the midline from the dorsal edge of the foramen magnum to the highest part of the skull.

Mandible Height is the greatest height of the lower jaw.

Mandible Length is the greatest length of the lower jaw. (The absence of a lower jaw, and hence the impossibility of obtaining the mandible measurements, does not mean that a data sheet is not required for that skull; an incomplete set of data is better than none at all. Similarly, if skulls are damaged, those measurements that can be taken should still be recorded).

AGE DETERMINATION FROM TEETH

- The paper Age estimation of the White Rhinoceros (Hillman Smith A.K.K., N.Owen-Smith, J.L.Anderson, A.J.Hall-Martin & J.P.Selaladi, 1986, J.Zool.Lond.(A) 210;355-379) is used as the basis for age determination from teeth, and of the field age determination outlined in section 5. A copy is appended at the rear of the document.

- Tooth impressions are taken from live immobilised rhinos using a wooden hinging mouth gag and dental alginate in a supporting tray made of dental acrylic. A plaster of paris mould is later made of the impression and labelled.

- From a skull, measurements are made and wear classified according to the above paper.

13. RHINO MORTALITIES

If a dead rhino is found, the following actions should be taken:

- Report immediately by radio
- Ascertain cause of death as far as possible. If it is freshly dead, suspected killed by poachers, avoid trampling on spoor, follow any signs and try immediately to apprehend the poachers.
- Try to determine relative age and sex of rhino and identification, giving evidence of why.
- Collect information as per the Rhino Mortality form.
- Collect any evidence of cause of death, eg bullets and note position.
- Collect a small piece of tissue for genetic analysis from as fresh a place as possible, eg heart, without touching the tissue by hand. Put into clean glass or plastic bottle or plastic bag and label with date, location, rhino, tissue, cause of death etc.
- Measurements should be taken as far as possible according to the Rhino Measurements form, preferably by a researcher.
- As directed or with RPO or MRC collect whole head including lower jaw and skin and ears.
- Transponders if present are in forehead skin and left neck. Collect any of this skin.
- Classify carcase according to time since death:

1 Fresh carcase (< 1week)
2 Recent bones with rot patch present
3 White bones without rot patch
4 Grey bones (flaking and breaking down)

TRANSPARENCIES/PRINTS FOR EXERCISES AND TESTS

HABITAT AND CONDITION

HA1. HP C
HA2. HP MA
HA3. HP MB
HA4. HP NZ
HA5. HP LO
HA6. HP MB T
HA7. HP MA A

ACTIVITY

HA8. MAN CT
HA9. DOR LO
HA10. VAU MA
HA11. MAR MB
HA12 COU MA
HA13 DEB LO T

ASSOCIATED SPECIES

HA15. Egret EGR
HA16. Yellow billed oxpecker YBO
HA17. Buffalo BUF
HA18. Kob COB

SEX DETERMINATION

SA1. Male
SA2. Female
SA3. Male
SA4. Female
SA5. Female

AGE DETERMINATION

SA6. I2 2-3mth
SA7. J2 10-11mths
SA8. J3 17mths
SA9. A.SA.SA.I
SA10. I/J 3mths
SA11. SA

TESTS

TEST 1

1.2.3.	2 AdF. I	F4
4.	3 SA	
5.	1 AdF	F1
6.	1 AdF	F6
7.	1 AdM	M2
8.	1 AdF	F4
9.	1 SAF 1 SAM	3b,3c
10	1 AdM	M9
11.	1 SAM	3aa/6c
12-15	3 AdF.AdM.I	F6.M2.6d

TEST 2

Complete data sheet for each observation.

1.	1	Ad	DEB	H MB	A		
2.	3	SA	MAN	H MB			
3.	2	AdJ	DOR	H LO			
4.	2	AdJ	COU	H MA			2 YBO
5.	1	SA	DEB	H MB			
6.	1	M	MAN	H MA	T		6 EGR
7.	1	Ad	MAN	H MB	T		
8.	2	Ad,SA	MAR	H MA	T		6 ELE
9.	2	Ad,I	DEB	H MA			
10.	1	AdM	MAR	H MA			3 YBO

TEST 3

Complete Fiche de l'Activite

1.	3	AdF.SA.		DOR	REP	DOR	H MB	T	2 2 2	
2.	2	SA.SA		MAN	MAR		H MA	T	5	3 EGR
3.	1	SAM		MAN			H MA	T		6 EGR
4.	2	FAdJ	F4	DEB	DOR		H MB	A	1	
5.	2	FAdJ	F4	DEB	DEB		H LO		1	
6.	2	SA		COU	COU		H LO		5	
7.	2	FAd,1	F4	MAR	DEB		H MB	T	2	3 YBO
8.	3	SA.SA.Ad		MAN	MAN	MAN	H MA	T	1 10 10	3 EGR
9.	3	AdF.J.SA	F3	DAL	DAL	DAL	H MA	T	2 5 5	
10.	2	SA.SA		VAU	VAU		H MA		5	

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Age estimation of the White rhinoceros (*Ceratotherium simum*)

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(*Accepted 21 January 1985*)

(With 4 plates and 5 figures in the text)

Age estimation criteria for the southern White rhinoceros (*Ceratotherium simum simum*) are presented both for free-ranging live animals and for cranial material. These are based on: (i) size appearance and horn development of live animals, (ii) stages of tooth eruption, (iii) tooth wear classes; (iv) attrition in height of the first molar tooth; (v) counts of cementum lines visible in tooth sections. Selected measurements are presented for live animals, skulls and horns.

For live animals, eight size classes are distinguished, seven of these covering immature animals up to ten years of age. Sixteen tooth wear classes are established based on eruption and surface wear of maxillary dentition. Chronological ages were assigned from individually known animals followed in the field, and from skulls from animals for which exact records of age were available, or which could be assigned to an age category from appearance at death. Cementum line counts corresponded approximately with age in years, despite difficulties in interpreting lines. Some variability was observed, possibly related to nutritional conditions.

The maximum cementum line count obtained indicates a longevity of at least 40 years. Full body weight and socio-sexual maturity are attained by males between 10 and 15 years of age, while females first give birth between six and eight years of age. Sequences and times of tooth eruption are similar to those reported for the Black rhinoceros (*Diceros bicornis*).

Comparative cranial and body measurements are presented for the northern subspecies (*Ceratotherium simum cottoni*).

Contents

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Introduction

For studies on mammalian population dynamics and their application in wildlife management, criteria are needed for assigning animals to particular age classes. These criteria are particularly difficult to establish for large, long-lived mammals like rhinoceroses (Perissodactyla: Rhinocerotidae), due to the lack of discrete breeding seasons, and the fact that stages of immaturity are spread out over several years. Moreover, there are the practical problems of securing sufficient material from populations that are relatively sparse, and frequently specially protected because of their rarity. However, it is particularly for such rare species that this information is needed in order to assess population trends and hence conservation status.

In this paper, we present age estimation criteria for the White or Square-lipped rhinoceros, *Ceratotherium simum*. These cover (a) visual features that can be applied to free-ranging live animals; (b) cranial characteristics, especially aspects of dentition such as the time of tooth eruption, wear patterns and counts of cementum lines visible in sectioned teeth (Morris, 1972) that can be applied to found skulls. For the Black rhinoceros (*Diceros bicornis*), age estimation criteria have been reported in terms of field characteristics by Schenkel & Schenkel-Hulliger (1969) and Hitchins (1970), while dental features have been described in detail by Goddard (1970) for East African animals, and Hitchins (1978) for South African specimens. For White rhinos, the early pattern of tooth eruption in calves has been described by Bigalke *et al.* (1950) and Dittrich (1972). Apart from this, there have been no previous publications describing dentition and other age estimation criteria for White rhinos. All specimens described in this paper are from the southern race, *C. s. simum*.

Materials and methods

Field criteria

Age estimation criteria for live animals were developed as part of a field study carried out by N.O-S. in the Umfolozi Game Reserve in Natal between 1968 and 1971 (Owen-Smith, 1973). All adult White rhinos and many subadults could be identified individually from variations in horn sizes and shapes, and 35 animals were marked with identifying ear-tags. Initially, immature animals were assigned to size classes based on height relative to that of an accompanying adult female, and on the size of the horns estimated in terms of ear-lengths. During the course of the study, known individuals were photographed repeatedly in order to record their development over the 2·8-year period of observation. By matching the appearance of younger age classes at the termination of the study with photographs of older age classes taken at the start, it was possible to piece together a complete sequence of development in relation to age. Growth in height with age was assessed from repeated photographs of known individuals, whose ages were known to within ± 1 month for animals younger than 6 months, and ± 2 months for animals aged between 6 and 12 months, when first seen. Photographs were taken so that the calf was standing close in front of its mother in lateral perspective, with the camera approximately level with its back, so as to reduce perspective distortion. The point where the top of the pre-sacral crest (the highest point of the body) reached was marked on the side of the image of the adult female, and height was measured from the feet of the adult to this mark, relative to the pre-sacral height of the adult in the photograph.

Weight ranges are based on estimates made by Natal Parks Board personnel involved in capturing White rhinos for translocation. The prior estimates made at the time of capture agreed closely with the subsequently measured weights of 8 young rhinos transported to Zimbabwe (Condy & Davison, 1964). These estimates are supported by a few weights that were measured for animals found dead in the field, which could be assigned to size classes on the basis of other measurements made (P. M. Hitchins, pers. comm.).

Standard measurements were taken from live animals that had been immobilised for ear-tagging or placement of radio transmitters. Measurements include horn length (along the anterior curve), basal circumference of the anterior horn, head circumference (measured between the 2 horns in earlier specimens, but subsequently behind the posterior horn with the tape extending over the eye), spine length (occiput to base of tail), and heart girth (round the body behind the shoulder).

Cranial characteristics

All rhino skulls and mandibles found during the field study in Umfolozi Game Reserve were collected and photographed by N.O-S. to show dentition. Animals that were encountered freshly dead could be assigned visually to age classes, so that approximate ages were established for the subsequently collected skulls. The sample includes one juvenile for which the exact month of birth was known (Table I, Plate IIIa).

Found skulls from Umfolozi were supplemented with skulls from animals that had died in Pilanesberg Game Reserve, Bophuthatswana, including some animals shot as trophies. All skulls were examined by A.K.K.H-S. with the assistance of J.P.S. and J.L.A. to establish dental and cranial characteristics for age determination. Skulls were grouped into wear classes according to the stages of tooth eruption and attrition and measurements of the first permanent maxillary molar (M^1). They were related to the dental appearance of animals whose age at death was known, or estimated from size and appearance. These included photographs of 4 skulls from Umfolozi animals that had been encountered by N.O-S. shortly after death, and 5 skulls from animals kept in a 2·5 km^2 enclosure near Pretorius Kop Camp in the Kruger National Park, for which age records had been kept (supplied by A.J.H-M.) (Table I). For early stages of

TABLE I
Known-age skulls used in assigning chronological ages

Source locality	Material	Label	Sex	Age
Kruger Park enclosure	complete skull	K1	female	9 y 7 m
Kruger Park enclosure	complete skull	K2	male	4 y 0 m 3 d
Kruger Park enclosure	complete skull	K3	female	6 m 24 d
Kruger Park enclosure	complete skull	K4	female	6 m 21 d
Kruger Park enclosure	complete skull	K5	female	10 y 4 m
Umfolozi Reserve	photographs	N0	male	4 ± 1 y
Umfolozi Reserve	photographs	N8	female	5 ± 1 y
Umfolozi Reserve	photographs	N20	female	14 ± 1 m
Umfolozi Reserve	photographs	N27	female	3·5 ± 0·5 y

FIG. 1. Definitions of tooth eruption and wear stages.

tooth development, reference was made to the published reports of Bigalke *et al.* (1950) and Dittrich (1972) based on captive calves. Both the Kruger and Pilanesberg populations are derived from animals translocated from the Umfolozi Reserve. The total sample comprised 74 skulls.

A tooth was defined as erupting when the tip protruded above the bone of the maxilla or mandible, and as fully erupted when the tip began to show wear. Subsequent wear stages were based on the degree of attrition of the enamel cusps and channels visible on the surface. The wear stages differentiated are presented in Fig. 1. The patterns recorded for each tooth were combined to yield an overall dental description of the complete maxilla or mandible. Fairly obvious changes, such as the eruption of a new tooth, were used to separate overall wear classes. Classification was based on maxillae for which sample size was larger and eruption/wear stages more uniform than for mandibles. However, tooth eruption and wear patterns are also described for corresponding mandibles, since these are more easily transported and stored than the bulky skulls.

The maximum height above bone level and maximum width were measured for a maxillary first molar (M^1), or, in young animals where M^1 was not fully erupted, for the first deciduous premolar (pm^1). First molar teeth were removed from the skull, and crown height was measured on the buccal side from the lowest point between the buccal crests to the saddle between the roots, as described by Spinage (1971, 1972).

Cementum line counts. A maxillary M^1 from each skull was cut in half using a hacksaw. The angle of cut was maintained constant as far as possible: vertically, bucco-lingually through the tooth between the anterior and posterior roots and through the cementum pad. The cut surface was polished using 2 grades of carborundum paper (p120 and p360) and metal polish, to give a smooth surface. The surface was examined through a binocular microscope using an oblique light source. The cementum shows alternate light and dark lines. Light lines only were counted. The lines frequently subdivided along their lengths, particularly in teeth from older animals. The number of lines was assessed by following lines along their lengths to eliminate those that were merely subdivisions, and by taking a mean value from counts at different points along the cementum pad. As a further check, counts were made on the same specimen by different observers, and the overall mean value used.

From a sample of 2 skulls for each age class, every tooth on one side of the maxilla was removed, cut and the cementum lines counted. This was done to determine the relative ages of eruption for each tooth.

External cranial measurements, as defined by Roberts (1951), were made for all skulls. Horns were also measured where available. The lengths of both the anterior and posterior horns were measured along the curve, while basal circumference was measured along the rim where the horn joined the skull.

Results

(a) *Field criteria for live animals*

Labels and definitions of the size classes established in the field study are presented in Table II, together with the estimated age range. Measurements of horns and body dimensions and estimated ranges in weight are presented in Table III. Five size classes represent juveniles, i.e.

TABLE II

Size classes used in field ageing of White rhinos in Umfolozi Game Reserve

Category	Label	Definition based on height relative to an adult female	Est. horn length (in ear-lengths*) anterior	Est. horn length (in ear-lengths*) posterior	Est. age range (months)
Infant	I1	Height below adult's shoulder fold	bump	none	0-2
Infant	I2	Slightly larger, still lacking posterior horn	lump	none	2-4
Juvenile	J1	Pre-aural crest not more than half-way up side of adult	¼	discernible	4-9
Juvenile	J2	Pre-aural crest up to top of adult's flank fold	½	bump	9-18
Juvenile	J3	Pre-aural crest up to top of adult's iliac projection	¾-1	knob	18-30
Subadult	S1	Pre-aural crest not above adult's sacrum	1-1½	knob	30-72
Subadult	S2	Discernibly smaller than an adult	1½-2	½-¾	72-120
Adult	A	Fully grown	1½-4	½-1½	120-480

*One ear-length = 23 cm for class J3, 26 cm for adult.

TABLE III

Measurements for immobilized White rhinos within each size class in Umfolozi Game Reserve

All lengths in cm, weights in kg. Upper figure = mean; lower figures = range. Also included are measurements for dead or captured animals corresponding to measured weights, supplied by P. M. Hitchins

Label	Sex	Sample size max.	Sample size min.	Horn length ant.	Horn length post.	Ant. horn basal circ.	Head circum. between horns	Head circum. post horns	Spine length	Heart girth	Est. weight range
I1		–	–		–		–		—	–	40-110
newborn infant[a]	♀	1	1						82	94	75*
small infant[b]	♀	1	1						99	119	115*
I2											110-180
J1										–	180-400
small juv.[c]		–	–			–	–	–	—	–	261*
J2							—		—	—	400-600
				25	7	45		104	202	208	
J3	♂	4	4	23-28	6·5-7·5	42-48	—	102-107	195-207	206-210	600-800
				27	9	46	—	93·5			
	♀	2	2	23-30							
injured[d]	♂	1	1	24	5	—	—	—	183	206	687*
				39	13	55	107	121	218	238	
S1	♂	5	1	34-47	9-16	45-60	102-109	119-122			800-1200
				35	11	50	100	116	226	240	
	♀	7	4	27-41	7-16	46-54	100-101	111-122	223-231	228-252	800-1100
dead[e]	♂	1	1	—		—	—	–	224	238	1090*
				53	16	69	121	137	262	288	1200-2000
S2	♂	6	3	41-57	15-21	67-72		133-144	256-270		
				46	16	60	119	129	246		1100-1500
	♀	3	1	43-52	15-17			127-132		—	
				60	26	75	125	144	269	284	2000-2400
A	♂	9	4	43-69	16-39	70-79	121-130		259-284	260-328	
				69	20	66		130	262	286	
	♀	6	5	52-82	16-26	65-68	—	126-137	248-273		1500-1700
killed[f]	♂	1	1	–	–	—	—	—	—	—	2130*

a umbilical cord present but dry, est. age 2 d, but probable age c. 3 wks; b—est. age 3 wks, but probable age 2 m; c est. age 5·5 m; d gored by another rhino, destroyed; e dead from horn wounds; f killed and weighed in the field in sections; * measured weights.

animals that were generally still accompanying their mothers. Separation from the mother usually took place between two and three years of age at the time of birth of the subsequent offspring. Two classes of subadult were distinguished, with the division between them corresponding roughly to the age at sexual maturity. In Umfolozi, females generally gave birth to their first offspring at about 6–7 years of age (Owen-Smith, 1973). In zoos, the mean age at first parturition was 5 y 10 m for known-age animals ($n = 6$, range 5 y 1 m – 6 y 2 m), and c. 8 y for animals for which only the year of birth was known (Lindemann, 1982). Zoo records show that males can become sexually potent at six years of age, but in the wild males do not become sexually active until they acquire territory holding status at about 10–12 years of age (Owen-Smith, 1975).

Photographs of known-age individuals representing each size class are presented in Plates I and II. A curve for growth in height of known-age calves relative to the mother, based on measurements taken from photographs, is presented in Fig. 2. Kirby (1920) gives the shoulder

PLATE I. Photographs of known-age White rhinos in Umfolozi Game Reserve: infant and juvenile size classes. (a) newborn I1 male, age 3 d; (b) infant I1 male, age 22 d; (c) infant I1 male, age 7 wks; (d) infant I2 male, age 4 m; (e) juvenile J1 male, age 6-7 m; (f) juvenile J2 male, age 11·5 m.

PLATE II. Photographs of known-age White rhinos in Umfolozi Game Reserve: juvenile and subadult size classes. (a) juvenile J3 male, age 18·5 m; (b) juvenile J3 male, age 22 m; (c) subadult S1 female, age 3·5 y; (d) subadult S1 male, age 5 y; (e) subadult S2 female, age 6 y; (f) subadult S2 male, age 8 y.

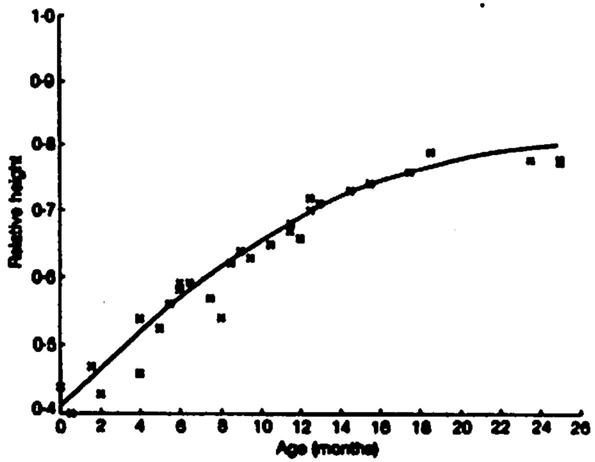


FIG. 2. Growth in height with age of White rhino calves, based on photographic measurements of height relative to that of an adult female.

heights of two adult specimens selected for their large size as: male—179 cm; female—177 cm. Foster (1960) lists the shoulder heights of four specimens (sex not stated) as 171–185 cm. The shoulder heights of two adult males measured while recumbent after immobilization were 178 cm and 174 cm, respectively (P. M. Hitchins, pers. comm.).

Measured weights are sparse. There is only one record of a measured weight for an adult. This is derived from a youngish adult male, with the last molar not fully erupted, that was sectioned and weighed in the field for the purpose of estimating the drug dosages required for immobilization. This animal weighed 2130 kg (J. Clark, pers. comm.). Maximum weights estimated for males are about 40% greater than those estimated for adult females; but, from the relatively small differences in linear measurements between the two sexes (Table III), the weight difference is probably exaggerated.

Two measurements clearly separate adult males and adult females into discrete groups: head circumference, and the basal circumference of the anterior horn. Male horns are stouter, but tend to be shorter, than those of females. Some females exhibited an anterior horn that projected strongly forwards rather than upwards, but this aberration was not observed in any male.

(b) *Cranial features*

Dental formula

The typical dental formula for White rhino is:

Deciduous: i 0/0, c 0/0, pm 4/4
Permanent: I 0/0, C 0/0, PM 3/3, M 3/3

The deciduous premolars 2, 3 and 4 are replaced by permanent premolars, while premolar 1 is not replaced. Individual aberrations recorded among skulls (n = 74) include the retention of a relict pm¹ in a maxilla in wear class XIV (22-23 y), and in a mandible of wear class X (8-11 y). A tooth developing posteriorly to M³ was found in one maxilla from wear class XI (10-15 y). There were no signs of incisors or canines in any specimen in the sample.

Tooth eruption

Deciduous teeth. Bigalke *et al.* (1950) document the full sequence of eruption of the deciduous teeth for 'Zuluana', a calf acquired by the Pretoria Zoo in 1946 at the age of 6 days. However, the growth of this animal, fed on a mixture of cow's milk and maize-meal porridge, was evidently retarded compared with the measurements reported for a White rhino calf born in the Hanover Zoo allowed to nurse from its mother (Dittrich, 1972). For instance, the weight of 'Zuluana' increased from 48 kg on arrival to only 63 kg at 3 months of age. In comparison, the Hanover calf increased in weight from about 40 kg at birth to 100 kg at 51 days and 145 kg at 105 days. Tooth eruption in 'Zuluana' tended to be retarded by about 30 days compared with the Hanover calf (Dittrich, 1972).

The deciduous premolars pm³ and pm² erupt in close synchrony in both jaws. In both the Hanover calf and 'Zuluana', the first tooth to appear was a mandibular pm³, at an age of 42 days in the former animal, and 77 days in the latter. In another calf captured from the wild at an age of 22 days, the first premolar appeared at an age of 70 days (Walluch, 1969). In 'Zuluana', the lower pm⁴ teeth appeared at an age of 83 days, and the upper ones at 140 days; while premolar pm¹ first appeared in the upper jaw at 358 days, and in the lower jaw at 389 days (Bigalke *et al.*, 1950).

Permanent teeth. From the sample of skulls, it is evident that the first permanent premolar, PM², begins to erupt between three and four years of age (Table IV). Premolars PM³ and PM⁴ erupt in sequence after PM², and only after about eight years of age are all permanent premolars in wear.

Molar M¹ begins erupting before the first permanent premolar at an age of about three years and comes into wear between three and four years. There were differences in the wear shown by the M¹ between two Umfolozi skulls and a Kruger Park skull of similar age. Skulls N8 and N27 from Umfolozi, with ages estimated to be 5 ± 1 y, and 3·5 ± 0·5 y, respectively, both have M¹ at wear stage 4. However, the Kruger Park skull K2, from an animal exactly 4 y 3 d old at death, shows M¹ only just starting to wear (wear classes 2 and 3 on opposite sides), as also does a third Umfolozi mandible with an estimated age of 4 ± 1 y (N0). Molar M² erupts between 4 and 7 years of age, and M³ between 8 and 16 years.

Tooth wear classes

Sixteen tooth wear classes were distinguished (Table IV, Fig. 3), though these show some overlap in assigned ages. Photographs showing the dentition for known-age specimens representing particular age classes are presented in Plate III. Tooth eruption and wear generally take place concurrently in both upper and lower jaws, but more variation in wear was shown by mandibles from older age classes than by maxillae. Corresponding teeth from opposite sides of the same jaw may occasionally show differing wear stages.

Tooth measurements

The crown height of maxillary M¹ teeth increases through wear classes V to VII (ages 1·5-4 y), indicating continuing growth (Table IV). The height of M¹ above the jaw bone, which is a

TABLE IV

Wear classes of the dentition for White rhino maxillae and mandibles, and cementum line counts

Numbers represent the tooth wear stages defined in Fig. 1. Where necessary, a range of stages is given, e.g. 3/4; 0 indicates this tooth is absent. Tooth measurements and cementum line counts are given as mean ± standard deviation

Age class	Assigned ages	Known-age material	n	Maxilla: Deciduous premolars pm¹	pm²	pm³	pm⁴	Maxilla: Permanent premolars PM²	PM³	PM⁴	Maxilla: Molars M¹	M²	M³	Mandible: Deciduous premolars pm¹	pm²	pm³	pm⁴	Mandible: Permanent premolars PM²	PM³	PM⁴	Mandible: Molars M¹	M²	M³	Maxillary M¹ measurements: Width (cm)	Crown height (cm)	Height above jaw (cm)	Cementum lines
0	0-1·5 m	Zuluana, Hanover	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	–	–	–	–
I	1·5-2 m	" "	1	0	1/2	1/2	0	0	0	0	0	0	0	0	1/2	1/2	1/2	0	0	0	0	0	0	–	–	–	–
II	2-4 m	" "	1	0/1	2/3	2/3	1/2	0	0	0	0	0	0	0/1	2/3	2/3	2/3	0	0	0	0	0	0	–	–	–	–
III	4-12 m	" "	3	1/2	3/4	3/4	2/3	0	0	0	0	0	0	1/2	3/4	3/4	2/4	0	0	0	0	0	0	–	–	–	–
IV	12-18 m	K3, K4, Zuluana, N20	3	3/4	4/5	4/5	2/3	0	0	0	0/1	0	0	2/3	4/5	4/5	3/4	0	0	0	0	0	0	–	–	–	–
V	1·5-3 y		3	7/8	6/7	5/6	4/5	0	0	0	1/2	0	0	8	6	6	4/5	0	0	0	2	0	0	2·6 ± 0·2	8·8	1·4 ± 0·2	0
VI	3-4 y	K2, N0	7	8/9	7/8	6/7	5/6	0/2	0	0	2/3	0/1	0	8/10	8/9	7/8	6/9	0/1	0/1	0/1	2/3	1	0	2·7 ± 0·2	9·3 ± 0·6	3·3 ± 0·5	0·3 ± 0·2
VII	3·5-4 y	N27	6	0/9	8/9	7/8	6/7	2/3	0/1	0	4/5	1	0	9/0	8/9	8/0	7/8	1/3	1	0	4/5	0/1	0	3·2 ± 0·6	9·7 ± 0·6	4·5 ± 0·2	0·3 ± 0·3
VIII	4-7 y	N8	11	0/9	0/9	0/8	7/8	3/4	1/2	1	4/5	2/3	0	9/0	9/0	8/0	7/8	3/8	1/7	1/7	4/6	2/5	1/2	3·8 ± 0·4	9·1 ± 0·4	4·7 ± 0·3	2·0 ± 1·0
IX	7-9 y		4	0	0	0	0	5/6	4/6	1/2	5/6	3/4	1	9/0	9/0	9/0	9/0	4/7	5/7	3/7	5/7	3/7	1/3	4·0 ± 0·2	7·9 ± 1·0	4·6 ± 0·5	5 ± 1·0
X	8-11 y	K1	3	0	0	0	8/9	7/8	6/7	2/3	6	4/5	1	0	0	0	0	6/7	6/7	3/7	5/9	3/7	1/4	4·3 ± 0·2	7·1 ± 0·4	4·3 ± 0·4	7 ± 1·5
XI	10-15 y	K5	9	0	0	0	0/9	8	6/7	3/5	6/7	4/5	2	0	0	0	0	5/8	6/8	4/7	5/8	4/6	2/4	4·5 ± 0·3	6·4 ± 0·3	4·6 ± 0·2	9 ± 2·0
XII	14-20 y		9	0	0	0	0	8/9	7/8	6/7	7/8	5/6	2/3	0	0	0	0	6/8	7/8	5/7	6/8	5/6	1/4	4·3 ± 0·3	5·3 ± 0·4	4·2 ± 0·3	14 ± 2·6
XIII	20-28 y		8	0	0	0	0	0/8	8	8	7/8	6/7	4/6	0	0	0	0	7/10	7/9	7/8	6/10	5/8	4/5	5·2 ± 0·6	3·6 ± 0·8	3·3 ± 0·5	22 ± 4·0
XIV	25-32 y		8	0	0	0	0	0/9	8/9	8	8	7	6	0	0	0	0	7/10	8/9	7/8	7/10			6·0 ± 0·5	3·1 ± 0·8	2·5 ± 0·5	26 ± 7·0
XV	30-38 y		4	0	0	0	0	–	–	8/9	9	8	7/8	0	0	0	0	8/10	8/9	8/10	8/10	7/10	6/7	5·6 ± 0·1	1·6 ± 0·3	1·2 ± 0·3	31 ± 7·0
XVI	35-40 y		1	0	0	0	0	–	–	–	–	9/10	9	0	0	0	0	–	8	0/10	10	8/10	7/8	–	–	–	32

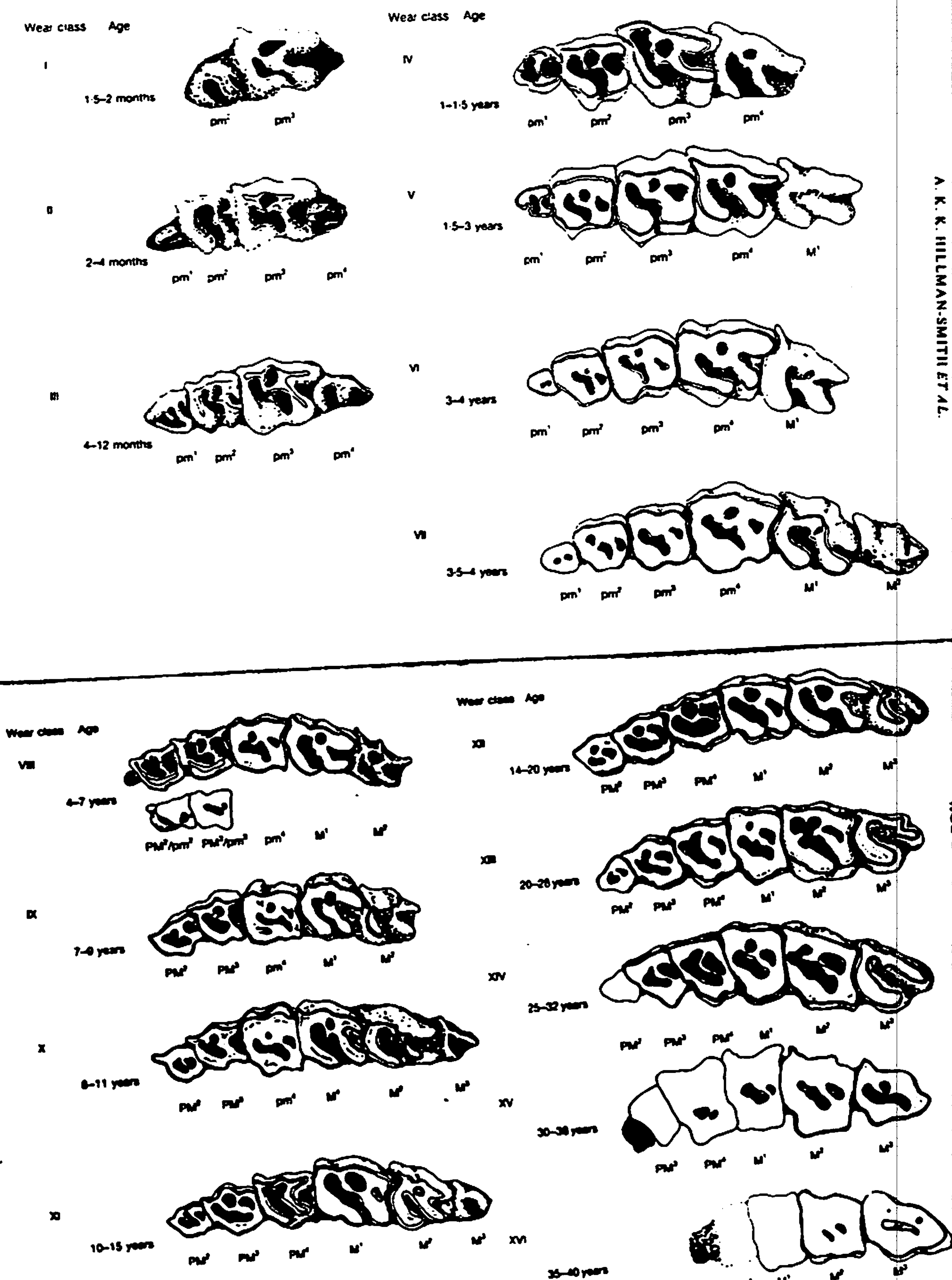
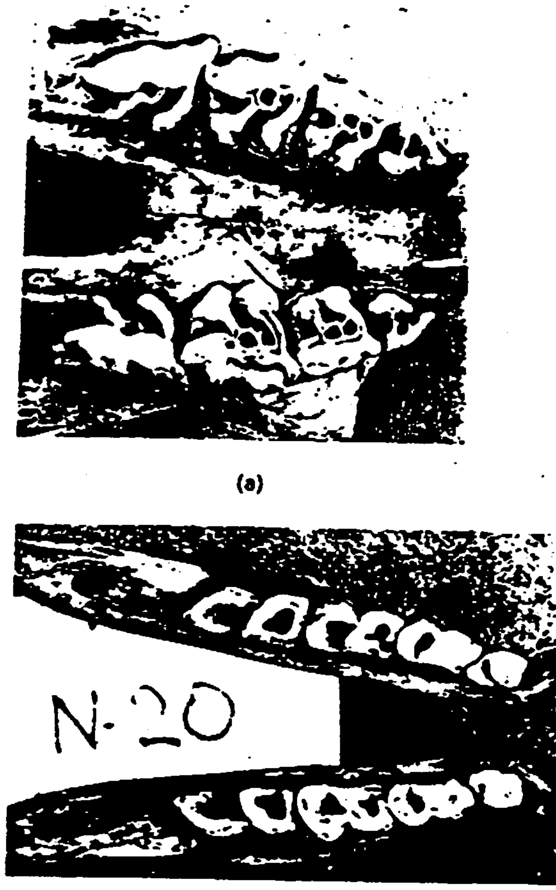
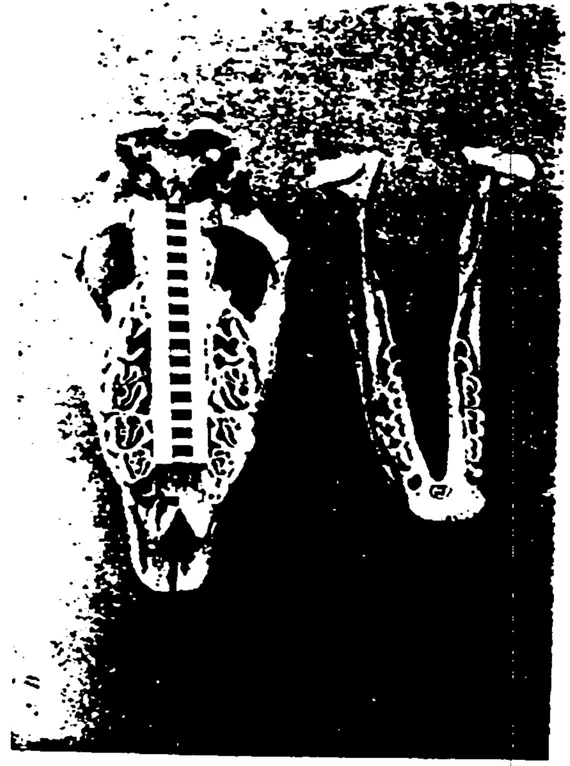


FIG. 3. Appearance of maxillary dentition in each of the tooth wear classes established

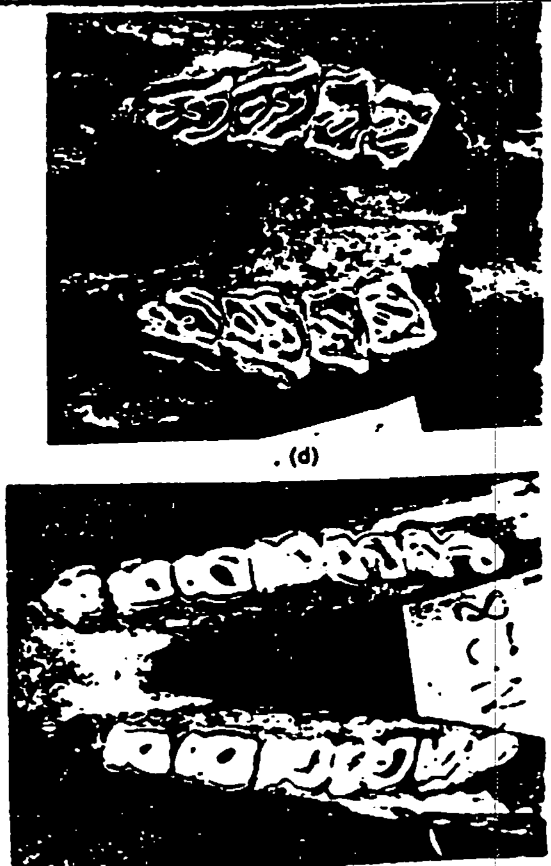


(a)



(b)

(c)



(d)

PLATE III. Photographs showing dentition of representative skulls. (a) juvenile female (N20) from Umfolozi, age 1 y 2 m, wear class IV. (b) subadult male (K2) from Kruger, age 4 y 0 m, wear class VI; (c) young adult female (K-5) from Kruger, age 10 y 4 m, wear class XI. (d) prime adult female (N28). 22 cementum lines counted in M¹, wear class XIII (note: pm² and m³ are missing from the maxilla).

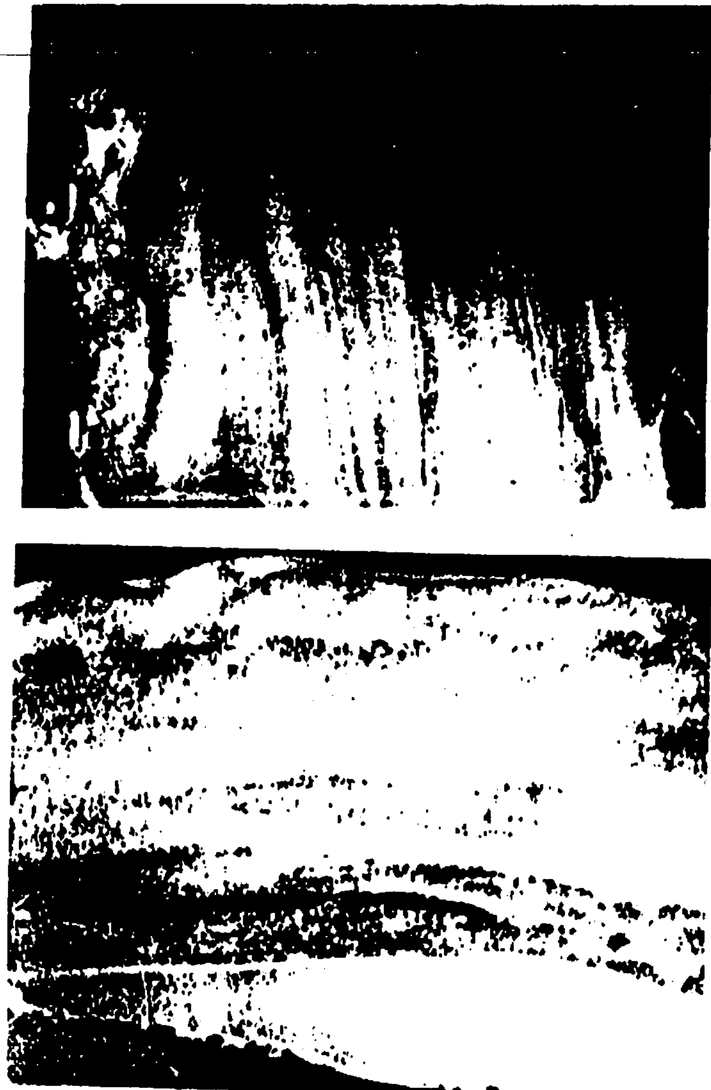


PLATE IV. Photographs showing cementum lines in M¹ teeth from White rhinos. (a) Specimen P27, wear class XII, showing approximately 20 cementum lines; (b) Specimen K1, age 9 y 7 m, wear class X, showing one part of a line of cementum in which approximately seven lines are visible.

TABLE V

Cementum line counts for complete sets of teeth (two skulls per class, maxillae only)

Wear class	Cementum lines (mean ± standard deviation)									
	pm^1	pm^2	pm^3	pm^4	PM^2	PM^3	PM^4	M^1	M^2	M^3
IV		1·0	1·5	0·5						
V	1·5	3·3±1·1	3·8±0·4	1·0±1·4						
VI	2·1±1·4	3·3±0·4	5·0±1·4	2·8±1·8						
VII	3·0	2·8±0·4	5·0	3·5±0·7				0·5	0	
VIII	4·0±1·4	3·0±0·7	4·8±0·4	5·3±1·1	0·5	0·5	0	2·6±1·2	0·5	
IX				5·5	0·5	0·5	0	4·0	0	
X				5·8±0·4	0·8±0·4	0·5	0·3	7·5±1·4	1·0	
XI					2·5	4·8±2·5	2·5	9·5±4·5	2·3±1·1	1·5±1·4
XII					4·0	4·0	3·3±3·9	16·5±1·4		1·0±0·7
XIII						22·0	17·5±5·4	24·0	14·5	7·0
XIV					12·0±1·4	15·7±2·5	11·0±3·0	22·7±7·6	10·0	5·2±2·6
XV							14·0	36·0	22·0	12·0
XVI									27·0	12·0

skulls for which sex was known, in addition to the combined means for all skulls. The skulls of adult males are consistently longer than those of females in the same wear classes. Although male horns tend to be slightly shorter, their basal circumference and weight are much greater than those of horns from similar-aged females.

Discussion

Rates of growth and development and tooth wear are not rigid features, but are subject to environmental modification. There is evidence that White rhinos are no different from other species in this response. The slow initial growth rate shown by the Pretoria Zoo calf, 'Zuluana', which was reared on an artificial diet, was associated with a retardation in the times of tooth eruption by about a month compared with another zoo calf that was able to nurse from its mother. Kruger Park animals that were confined to a 2·5 km^2 enclosure showed a delay in the eruption of the first molar by roughly a year compared with Umfolozi animals. Photographs of known-age calves from the Kruger Park show that the horn development of these animals was also slower than that of Umfolozi calves of similar age. Thus environmental factors introduce a degree of uncertainty in applying age ranges from body or horn size, or tooth eruption and wear, to animals from different areas.

The timing of tooth eruptions in White rhinos is closely similar to that reported for Black rhinos, for young calves by Dittrich (1972), and for older animals by Goddard (1970) and Hitchins (1978). In Black rhinos, rudimentary incisors are occasionally present, but this condition was not observed in any White rhino material. In White rhinos, the persistent pm^1 is lost between four and seven years of age, while in Black rhinos it invariably persists until 14 years of age or later in the maxilla, though in the mandible it is lost at about 12 years of age (Hitchins, 1978).

Cementum line counts provide a valid aid in assigning chronological ages to White rhinos, as has been found in other mammals (Morris, 1972). It appears that one pair of light and dark lines is formed per year, corresponding to the single rainy season typical of the study region. However, precision is limited by the difficulties experienced in interpreting lines, and by the diminishing

TABLE VI

External cranial and horn measurements for skulls corresponding to each wear class
(Figures are given as mean ± standard deviation)

Wear class	Sample size: Combined	Female	Male	Cranial measurements (mm): Greatest length	Dental concavity	Chondylo-basilar length	Chondylo-nasals	Foramen magnum-nasals	Inter-orbital constriction	Maxillary tooth row	Mandibular tooth row	Horn weight (kg): Ant	Post	Horn measurements (mm) ant: Length	ant: Basal circ	post: Length	post: Basal circ	Known age
III		1		304	21	326	302	287	85	125	125							
IV	1			—	—	—	—	—	97	140								7 m
V	3			480		530	498 ± 31	470 ± 30	89 ± 11	202 ± 8	205							
VI	7			565 ± 28	61 ± [illegible]	590	533 ± 30	509 ± 11	94 ± 5	203 ± 7	199 ± 4	2·5		419	654			
		1		565	70	—	480	505	91									
VII	5			637 ± 15	62 ± 9	630	593 ± 38	565 ± 46	90 ± 10	197 ± 12	202 ± 18							4 y 2 d
VIII	6			674 ± 32	67	670 ± 14	586 ± 20	561 ± 28	85 ± 5	230 ± 8	231 ± 33							
IX	3			657 ± 21	74 ± 8	—	593 ± 6	563 ± 6	87 ± 11	225 ± 5	—							
X	8			695 ± 36	83 ± 6	663 ± 26	611 ± 25	578 ± 28	91 ± 7	245 ± 7	250 ± 28	4·0 ± 1·4	1·3 ± 0·4	496 ± 144	354 ± 61	164 ± 21	523 ± 26	
		1		705	76	661	605	577	98									
XI	8			733 ± 35	84 ± 8	699 ± 26	618 ± 25	608 ± 37	95 ± 6	244 ± 12	263 ± 20	4·5 ± 1·8	0·5 ± 0·4	617 ± 62	637 ± 68	179 ± 63	522 ± 140	9 y 7 m
			6	748 ± 23	84 ± 9	699 ± 18	625 ± 19	620 ± 31	96 ± 3			3·0 ± 1·6		623 ± 66	656 ± 51	199 ± 59	550 ± 137	
		2		685 ± 7	70 ± [illegible]	660 ± 25	597 ± 35	570 ± 28	94 ± 13			3·0		584	523	127	381	
		1		710	76	675	595	575	90									
XII	7			740 ± 49	83 ± 9	695 ± 24	621 ± [illegible]	599 ± 31	95 ± 4	274 ± 11	272 ± 21	4·5 ± 1·3	0·8 ± 0·4	686 ± 76	686 ± 79	202 ± 77	670 ± 185	10 y 4 m
		2		700 ± 57	84 ± 5	685 ± 21	615 ± [illegible]	585 ± 21	96					616	743	216	692	
			5	756 ± 42	82 ± 10	634 ± 34	624 ± [illegible]	[illegible] ± 35	94 ± 4			4·5 ± 1·3		743 ± 62	734 ± 30	224 ± 14	753 ± 98	
XIII	9			740 ± 35	77 ± 3	679 ± 30	623 ± [illegible]	[illegible] 18	97 ± 6	247 ± 21	275 ± 7			607 ± 95	597 ± 180	188	580 ± 176	
		2		765 ± 21	82 ± 3	700 ± 25	630	[illegible] 4	93			2·8	0·5	527 ± 41	464 ± 18	139	387	
			2	765 ± 7	76 ± 2	690	635 ± [illegible]	602 ± 5	99					686 ± 18	720 ± 72	213 ± 4	677 ± 67	
XIV	7			756 ± 15	78 ± 11	716 ± 15	647 ± 15	623 ± 18	96 ± 8	270 ± 8	260 ± 11	6·0		679 ± 81	609 ± 114	218 ± 111	517 ± 224	
		2		755 ± 21	69 ± 1	705 ± 21	630 ± 28	610 ± 25	100 ± 6			4·0		730 ± 81	511 ± 23	175 ± 166	367 ± 243	
			3	765 ± 7	90 ± [illegible]	730	645 ± 7	625 ± [illegible]	93 ± 8			8·0		627 ± 52	707 ± 11	261 ± 45	667 ± 40	
XV	4			767 ± 40	79 ± 4				89 ± 9									
		1		720	76				95									
			2	790	81													
XVI			1	740	87				90			4·0	1·5	584	562	156	536	

distinctness of lines as teeth age. Cementum line patterns for Black rhinos described by Hitchins (1978) seem to be easier to count than those observed in White rhinos, though in Black rhinos clarity also decreases with chronological age. Possibly, seasonal fluctuations in food availability are more consistent for a browser like the Black rhino than they are for a grazer like the White rhino, for which grass growth is more directly dependent on the vagaries of rainfall.

For Indian rhinos (*Rhinoceros unicornis*), Laurie (1978) sectioned the tusk-like lower incisors to count cementum lines, which seemed to be fairly clearly defined. The maximum number of lines counted in his limited sample was 26. For Black rhinos, Hitchins (1978) counted a maximum of 34 cementum lines, which, allowing for the time of eruption of the M^1, suggests a chronological age of 37 years. This is in concordance with zoo records showing a potential longevity of 35-40 years (Goddard, 1970). For White rhinos, the maximum cementum line count was 36, suggesting an age of 39–40 years. Zoo records of potential longevity are unavailable for White rhinos, due to the limited period over which specimens have been kept. The oldest White rhino in a zoo is 'Zuluana', who is currently still alive in the Pretoria Zoo at an age approaching 38 years, though showing signs of senility.

For field age estimation, the defined size classes, aided by horn growth, allow White rhinos to be assigned to functional age classes as follows: (i) newborn infants—class I1 (0-2 m); (ii) unweaned infants (only small amounts of nibbling on grass)—classes I1 and I2 (0-4 m); (iii) calves likely to be still nursing—classes I1-J2 (0-18 m); (iv) calves generally still accompanying their mothers—classes I1-J3 (0-30 m); (v) adolescents independent of their mother, but not sexually potent for males and pre-parturient for females—class S1 (2·5-6 y); (vi) subadults, including males that are sexually potent but not yet full weight and thus not socially active in reproduction, and females that are late in producing their first calves—class S2 (6-10 y). Trophy size horns are attained at an age of 10–15 years, and no further increase in horn length or basal circumference was apparent.

Skulls of adult animals could potentially be sexed by relating either linear dimensions or circumference around the orbital region to tooth wear class. For adult horns, measurements of basal circumference would allow sex to be established fairly reliably.

In Table VII, the field size classes are related to the tooth wear classes. Patterns of tooth eruption, surface wear and attrition in height allow full-grown animals to be assigned to age ranges, which cannot be done reliably from visual observations of live animals. Dental patterns can potentially be examined, or impressions taken, in live animals that have been immobilized;

TABLE VII

Interrelation between field size classes, tooth wear classes and age

Size class	Wear class	Age range (months)
I1	0, I	0-2
I2	II	2-4
J1	III	4-9
J2	III, IV	9-18
J3	V	18-30
S1	VI, VII, VIII	30-72
S2	IX, X	72-120
A	XI—XVI	120-480

but in White rhinos this is difficult because of the limited extent of the gape. For younger age classes, ages could be assessed approximately from the sizes of either intact or isolated anterior horns.

The information presented in this paper provides a basis for estimating the ages of White rhinos either as living animals, as found skulls, or even as isolated horns. Immature animals up to six years of age can readily be assigned to age categories on the basis of relative size and horn development. Patterns of tooth eruption and wear may be used to assign ages to skulls from animals up to about 15 years of age, when the last molar erupts. Stages of tooth wear and measurements of M^1 height can be used to assign broad age ranges to skulls of older animals. Cementum line counts can provide supporting evidence for assigned ages; but because of problems of interpretation they provide little real gain in reliability in return for the effort required. Caution must be used in applying the age ranges given in this paper to White rhinos from other populations, because of potential variations in growth rates, timing of tooth eruption, rates of tooth wear and clarity of cementum lines, and the relative paucity of known-age material that was available to us.

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Addendum

Notes on dentition, cranial and body measurements of the northern White rhinoceros (*Ceratotherium simum cottoni*)

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For comparative purposes, similar measurements are presented for the endangered subspecies of the northern White rhinoceros (*Ceratotherium simum cottoni*).

Methods

Cranial measurements and dentition were recorded as above from the skulls of 6 wild northern White rhinos found dead in the Shambe area of South Sudan and Garamba National Park in northern Zaire, during a survey of the subspecies in 1983 (Hillman & Smith, 1983). They were also taken from a dead captive female at Vychodoceska Zoo, who originated from Shambe (by kind courtesy of Dr J. Safarik).

Body measurements of 8 live captive northern White rhinos of approximately known age (one measured twice at different ages) were provided by Mr M. Svitalsky and Dr J. Safarik of the Vychodoceska Zoo in Czechoslovakia. Those comparable to the measurements taken on southern White rhinos are presented here. One animal originated from Uganda, the rest from Shambe, South Sudan.

Results and discussion

The dentition and sequences of eruption and wear appear to be the same as those of the southern White rhinos and the same wear classes can be defined. There is insufficient material from known-age animals to verify whether the same ages would correspond with the same wear classes. However, the dentition of the captive female, who was estimated to have been born in 1972 and who died on 4 January 1982, is clearly that of eruption/wear stage X, which is defined

TABLE VIII

Cranial measurements (mm)

Origin	Wear class	Identification	Greatest length	Dorsal concavity	Condylo-basilar length	Condyles–nasals	Foramen magnum–nasals	Maxillary tooth row	Mandibular tooth row	M^1 width	M^1 ht. to jaw
S. Sudan (Shambe)	IV	S5				480	450	180	135		
	XI	S1		30		690		270			
	XII	S2	720			690		270			
	XII	S3	810	35		725	690	225			
Zaire (Garamba)	XI	O1	800	65	705	620	590	225	206	41·4	43·3
	XII	O2	710			680	550	270		44·0	44·0
S. Sudan (Shambe)	X	Nuri*	730	35	630			230	175	45·0	50·0

*Captive female, age at death 9–10 years

TABLE IX

Body measurements (lengths in cm, weights in kg)

Rhino names:	SUDAN	SAUT	SUNI	SUNI	NASIMA	NASI	NOLA	NADI	NESARI
Sex	M	M	M	M	F	F	F.	F	F
Age	10-11 y	c. 10 y	2 y 5 m 22 d	3 y 1 m 3 d	c. 14 y	5 y 19 d	c. 9 y	c. 10 y	c. 10 y
Wt. (approx.)	1600	1400	7 800	1100	1400	1600	1400	1500	1500
Back length		266	243	241	248	260	257	245	262
Head length			103	110	105				
Tail length	85	79	79	82	79	83	74	74	82
Shoulder ht. (St.)			143	147	154	156	150	152	151
Shoulder ht. (curve)		166	159	164	164	177	168	172	176
Chest circumference	302	298	262	273	284	309	301	307	322
Belly circumference		321	289	304	315	327	325	327	
Horn length, ant.			32	39	59	46	56	45	52
Foot circ., fore		85	82	85	77	85	93	88	89
Foot circ., hind		78	75	79	73	84	89	77	81

as including ages 8-11. The degree of wear on the teeth is somewhat less than that of many wild rhinos that are in the same age class due to eruption, and pm[1] was still present. Wear would, however, be expected to vary between live and captive rhinos. In general, as far as can be ascertained, the eruption/wear classes of the dentition of White rhinos as derived from the southern subspecies appear to be applicable to the northern subspecies.

The most obvious differences between the skull measurements of the two subspecies are the dorsal concavity and the maxillary tooth row, both of which are less in the northern subspecies of the same age class, as noted by Groves (1972). The reduced dorsal concavity of the skull is clearly recognizable in live northern White rhinos. Some of the skull measurements of these northern White rhinos appear to be larger than those of the equivalent age classes of southern White rhinos, although Heller (1913) noted that northern White skulls tend to be shorter than those of southern White rhinos.

The northern White rhinos appear to be shorter and smaller than the southern White rhinos of equivalent age in most cases. The captive female 'Nasi' is believed to be a hybrid between a male of the southern subspecies and a female of the northern subspecies. Even at the age of 5 years, she is taller at shoulder height than the other captive northern White rhinos and heavier than the other females. So far, insufficient data are available from known-age infants to compare development and age determination of northern White rhinos, but field observations to date indicate a similar size relationship with the mother to that found for southern White rhinos.

Within the limitations of the amount of data available on northern White rhinos at this stage, age determination techniques developed on southern White rhinos appear to be reasonably well applicable to northern White rhinos, with the exception of certain cranial measurements.

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